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Technology Review

Edited at the Massachusetts Institute of Technology

Arthur C. Clarke:

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Articles

Communications in the Second Century of the Telephone 32
Arthur C. Clarke

One of the world's leading writers of science fact and fiction turns his crystal ball on tomorrow's computers, telesafaris, autosecretaries, satellites, and infomania

A Tragedy of the Commons in the Sahel 42
Anthony C. Picardi and William W. Seifert

A system analysis of the sub-Sahara reveals why the sahel drought caused such devastation — and why most of the commonly proposed solutions can only make the next drought's devastation greater

U.S. Energy: The Plan that Can Work 52
Manson Benedict

No single strategy can resolve U.S. energy needs. A system so complex, and a demand so great, will require a sophisticated combination of many technologies and many resources

Resources and Economic Growth 60
Harvey Brooks

Materials shortages need not constrain future growth. The crucial issue will be the world political system's ability to allocate resources effectively between current consumption and future demand

Design for Communication in the Research and Development Laboratory 64
Thomas J. Allen and Alan R. Fusfeld

Communication is crucial to innovative research and development, and the design of their laboratory is a significant determinant of how well its users communicate with one another

Departments

Cover
Design by David Colley

First Line 2

Letters 2

Technology/Society 4
What hope for ordinary mortals, when those who teach conflict management cannot manage their own conflicts?
Kenneth E. Boulding

National Report 7
An essay on the limitations of paternalism in the effort to help others feed themselves
David F. Salisbury

Technology/Environment 8
A sorry history of man's insensitivity to one of the most unusual and most beautiful environments on earth
Ian C. T. Nisbet

Special Report 10
More than anything else, those who would help us assess the values and dangers of our technology need courage to do what they know how
George A. W. Boehm

Book Reviews 12
Thinkers and Tinkers: Early American Men of Science, reviewed by John B. Rae, **12**
Bicycling Science, reviewed by Edward Wheeler, **13**
Legal Aspects of the International Transfer of Technology to Developing Countries, reviewed by Stephen J. Kobrin, **14**

Trend of Affairs 16
Cancer, **16**
Food, **19**
Environment, **21**
Energy, **22**
Astrophysics, **23**
Telephones After 100 Years, **24**

Puzzle Corner 26
A fifth-grade homework problem makes the grade; can you solve it?
Allan J. Gottlieb

Institute Informant 30

The First Line

The Telephone and Its Revolution: Past and Future

In March, amidst the nation's noisy, happy celebration of its bicentennial, there was another much quieter birthday celebration — the 100th anniversary of the telephone. To mark the centennial of Alexander Graham Bell's first telephonic communication, M.I.T. and the American Telephone and Telegraph Co. joined on March 9 and 10 to sponsor a major "Convocation on Communications" in Cambridge, with sessions on the social impact of the telephone, its electronic cousin the computer, and new approaches to understanding how language develops and functions.

In this issue of *Technology Review*, we've begun opening the "birthday presents" from this gathering of leading communication scientists by publishing reports in our "Trend of Affairs" section and offering Arthur C. Clarke's concluding address, "Communications in the Second Century of the Telephone" (*pp. 32-41*). We express our thanks to the Convocation, and through it to A.T.&T., for permission to publish Mr. Clarke's paper, and we hope to have the privilege of bringing additional material from this Convocation into future issues of the *Review*. — *D.M.*

Letters

How to Heat a Frozen Cell

Ernest G. Cravalho states in "The Cryopreservation of Living Cells" (*October/November, pp. 30-37*) that today the cooling velocity is a much more important factor than the thawing velocity. But about 20 years ago, while I was visiting the Worcester Foundation, Hudson Hoagland told me that in his work on the cryopreservation of spermatazoa, he had reached just the opposite conclusion: inefficient warming procedures seemed to contribute more to cell death.

At that time, I suggested that someone look into the possibility of using commercially available diathermy machines for warming frozen cells. The idea was based on the fact that when cells absorb the radiation, heat is generated within the cell. Consequently, the rate of heat flow through the cell wall, or into whole tissue, would not be a controlling factor in thawing velocity. Since that time, I have made the same suggestion to others involved in similar work, but have never heard whether the idea was ever tried.

Edward R. Atkinson
Cambridge, Mass.

Dr. Atkinson is a Senior Chemist for Arthur D. Little, Inc. — Ed.

Dr. Cravalho responds:

In the case of cells treated with a cryophylactic agent, cooling velocity is generally a more significant parameter than warming velocity. But this is not to say that warming velocity is insignificant. The warming velocity can be more significant since the cryophylactic agent minimizes the effects of cooling velocity but usually does little to improve the situation with respect to warming velocity. Of course there are exceptions in both cases.

Your suggestion regarding the use of diathermy for the thawing of cells is interesting. A number of attempts at such thawing treatments on tissue and organs have been made in laboratories around the country, but these have proven unsuccessful due principally to the variation of the absorption coefficient for microwave radiation in tissue, ice, and water. This variation is so great that it is possible to have charring, boiling, and melting all present simultaneously in a given sample. Recent attempts to use microwave thawing at the University of Minnesota have proven more successful since they use monochromatic radiation of different wavelengths at different times on the same sample. Although this new protocol is a step in the right direction, much work remains to be done.

Rx: Peer Review

The benefit of peer review of manuscripts is well illustrated by "The Cryopreservation of Living Cells" by Ernest G. Cravalho (*October/November, pp. 30-37*). For instance, Dr. Cravalho asserts that glycerol must be added to red cells collected in CPD [Citrate-Phosphate-Dextrose, an anticoagulant] more slowly than those collected in ACD [the anticoagulant Acid-Citrate-Dextrose], since CPD moderates glycerol transport in such a way that the cells are damaged prior to freezing. This is an unusual statement and not corroborated by any publication of which I or my blood-banking friends are aware.

Since ACD and CPD are virtually identical except for the ratio of citrate buffers and a small amount of phosphate in CPD, this statement, if true, is startling. Since no references are quoted, I assume the observation is Dr. Cravalho's, and it needs documentation. . . . Furthermore, he states that ACD and CPD find widespread usage today. ACD is widely used at a large Boston hospital, but not in any other Boston hospital or at the American Red Cross Blood Service to any extent. The ratio of CPD to ACD use nationally is approximately 8:1.

Later, Dr. Cravalho states, "In the body the half-life of red blood cells is about a month." This . . . surely is not correct if he is referring to the human body. Human red cells labelled with ^{51}Cr do appear to have a half-life of 25 to 35 days due to the elution of the label from the middle-aged cells. The mean half-life of human red cells evaluated by other means is well known to be 61 to 66 days.

Lawrence N. Button
Boston, Mass.

Dr. Button is Director of the Blood Preservation Laboratory at Children's Hospital Medical Center. — Ed.

Dr. Cravalho replies:

The issue of relative speed of glycerol uptake in CPD cells versus ACD cells is really no question to us. We have had a great deal of clinical experience at Massachusetts General Hospital with these two types of cell treatment. The situation is as I described in the article. We are now in the process of measuring these two rates directly on an apparatus developed in my laboratory, and we will be reporting these data in a few months. Further, even if M.G.H. were the only user of ACD, it processes 1,000 units of blood a week — widespread usage by any standards.

Concerning the half-life of red blood cells in the body, Dr. Button's statement is correct but requires considerable explanation to the lay reader. My own statement of the situation is not incorrect but it is only partially correct. Since the issue is not directly related to the theme of the article, it did not seem to merit the space and difficulty of a full explanation.

If the magazine were to adopt peer review as Dr. Button suggests, I think it would suffer. Peer review would mean

that virtually every statement of fact would have to be supported with references to the permanent literature. The net result is a sterile, technical journal of the sort already available in countless technical libraries. I think the educated reader reads these articles fully aware that some of the statements reflect the bias of the author, and that to me is one of the magazine's attractive features.

Due Credit

The cover for your January, 1976 issue includes a very striking image of the sun; we are proud that one of the Naval Research Laboratory's spectroheliograph images was so exhibited, but disappointed that we were not recognized. N.A.S.A.'s Skylab mission provided an unprecedented period of solar observation from space, where experiments like the spectroheliograph were operated by the astronauts.

The cover image was obtained on August 9, 1973, by N.R.L.'s spectroheliograph on board Skylab. The huge eruption from the surface of the sun reveals that the helium erupting from the sun can stay together to altitudes of 500,000 miles. The helium gas clouds seem to have come to a standstill, as though blocked by an unseen wall, and some material appears to have been directed back toward the sun as a rain, distinguished by fine threads. The magnetic fields and gravity must play a part in these curious forms, and studies of this and other events are being pursued with hope that valid explanations can be reached.

R. J. Schumacher
Washington, D.C.

Dr. Schumacher is Project Manager, Apollo Telescope Mount, for the Naval Research Laboratory. — Ed.

Pithecanthropus Italicus

"Tracing the Ascent of Man" (*February, pp. 6-7*) is interesting, but a little hard to follow because of the unusual orthography and capitalization.

By taxonomic custom, we capitalize the genera and leave the species lower case, with both names printed in italics. In this article, our genus, *Homo*, was not spelled with a capital, nor were other genera, "*Australopithecine*" (sic) or "*Pithecanthropus*."

"*Pithecanthropus dubious*" might be humorous, but should in any case be spelled "*dubius.*" And "*Australopithecine*," as a genus, would be spelled "*Australopithecus*," as all genera are nouns. Finally "*typical homo*" should not have "typical" in italics unless it is being defined as a species, in which case it would be "*Homo typicus.*"

Arthur J. Morgan
New York, N.Y.

A Measure of Satisfaction

Kenneth Boulding's "What Do We Know When We Know a Number" (*December, p. 10*) is out of step by 50 or 70 years in the notion that the metric system is a preposterous historical accident. Time in the S.I. (système internationale) is represented by the second, which can be expressed easily in decimal submultiples or multiples for engineering purposes.

Ask any person who uses the Celsius temperature scale, and they will assure you it is more satisfying psychologically than the Fahrenheit scale.

Louis F. Sokol
Boulder, Colo.

Mr. Sokol is President of the U.S. Metric Association, Inc. — Ed.

The change from the arbitrary inch to the arbitrary meter, making obsolete probably ten times the quantity of tools and data in the English-speaking world than exist in the metric world, is purely capitulation to Frankish chauvinism. The mismated conversion approximations and endless misfitting of repair and modification components, duplication of tool inventories and parts stocks, and lost time and labor constitute an enormous handicap. It will drag us down in competitive production and technological development for decades.

Charles C. Littell, Jr.
Dayton, Ohio

Crazy Humanity

I agree with Professor Boulding ("*The High Price of Technology Misused,*" *July/August, p. 5*) that "we will find something better than corrupt capitalism or tyrannical socialism" as a future restructuring of society. The symptoms of a democratic restructuring are already visible as witnessed by the greater involvement of workers in planning and management . . . in which the people are forcing changes that affect their lives.

There is a widespread distrust of all existing institutions whose operations counteract human ends and thus enslave the individual . . . A synthesis of technology and humanistic free enterprise in a viable democracy can come about as long as the human organism, as Prof. Boulding expresses it, remains "creative, lively and crazy," i.e. "crazy" enough not to accept any existing institution as a permanent, unalterable fixture.

Silvio Zanetti
Cambridge, Mass.

The Singular Breeder

"The Breeder Reactor in the U.S.: A New Economic Analysis" by Irvin C. Bupp and Jean-Claude Derian (*July/August, 1974, pp. 26-36*) proposes to summarize "the economic prospects for breeders." This statement uses breeders as plural. If the statement said "the liquid-metal fast breeder reactor," it would be true. There is more than one type of breeder, notably the helium-cooled reactor.

R. Tom Sawyer
Ho-Ho-Kus, N.J.

A-C from D-C Machines

In self-excited alternating operation of direct-current machines and of electrostatic influence machines, mechanical energy (the turning of the rotor shaft) is spontaneously converted into alternating electricity with no applied excitation. This occurs because, from a simplified circuit viewpoint, the speed voltages generated by the motion act like negative resistances, and so the natural frequencies can be in the right half plane with the positive real part resulting in exponential growth and the imaginary part giving the frequency of oscillation. (Of course, in any real system saturation effects limit the exponential growth.)

I believe that similar cross-coupling occurs in nature on a large scale, resulting in periodic reversals such as those of the earth's magnetic field discussed by George L. Siscoe ("*Solar-Terrestrial Relations: Stone Age to Space Age,*" *January, pp. 26-37*). What is needed is identification of the physical nature of the coupling. I believe that if I can cause spontaneous alternating generation of electric and magnetic fields with simple laboratory equipment, nature can surely do better.

Markus Zahn
Gainesville, Fla.

The writer is Associate Professor of Electrical Engineering at the University of Florida.

Speak No Evil

I wish to call your attention to a serious typographical error in your October/November issue ("*Can an Architect Be a Lady? Yes, Indeed,*" *p. 72*). Someone mistakenly used the word "lady" in the title. Women obviously can be architects, but when they resort to the gutter language quoted, then "ladies" they ain't.

Thomas H. May
Harrisburg, Penn.

Putting Our (Big)foot in It

I believe you and your readers ought to follow Dennis Meredith's advice to observe a healthy skepticism towards those reporting evidence. I include Mr. Meredith himself ("*The Loch Ness Press Mess,*" *March/Arpil, pp. 10-12*). I am the New York attorney who owns "Oliver," a very strange primate indeed. Whether or not he is a chimpanzee is still debated among those studying him. However, I never thought or claimed that Oliver is a Big Foot. The truth is that I too received the same treatment from *Time* accorded Dr. Rines, and accepted it as one of the risks of being involved in a highly controversial issue of public concern.

Mr. Meredith took the *Time* article, as

(Continued on p. 15)

A Sporting Chance

Technology/Society
by
Kenneth E. Boulding

Our inability to manage conflict probably causes more suffering than any other failure of human organization and intercourse. War, industrial strife, family quarrels, church schisms — the list approximates a catalogue of human ills.

Conflict is not an evil in itself; it can be productive of great good. We funnel enormous resources into institutions to manage conflict — the law, the police, the armed forces, psychiatry, mediation, clinical psychology, religion — yet we are always stumbling into conflicts that often do more harm than good. One of the most stubborn puzzles of the social sciences is why we manage conflict so badly.

I have hoped for many years — and still hope — that the social sciences would not only illuminate conflicts but also their resolution. Instead, I have seen at least three organizations dedicated to research in this area break up on the shoals of their own internal conflicts. Physicians, of course, are notoriously unable to heal themselves. But when those who teach conflict management clearly cannot manage their own, we surely have a long way to go.

Nevertheless, I have not given up hope. The work of the last 20 or 30 years has laid some solid foundations on which both the science and the specialized art of conflict management might be erected.

What Is Conflict Management?

I shall define conflict management as the favorable modification of all processes which involve redistributions of perceived welfare. That's a mouthful, but each element is essential.

The values of a conflict's manager — who may be a person, a law, or an institution — decide what is "favorable." In a certain sense, values exist only in human minds. Nevertheless, conflict management is inescapably a normative discipline concerned with values as well as facts. This is not to deny its integrity as a discipline. Values are not random, and anything which is not random may be subjected to disciplinary study.

"Modification" gets us into even more trouble than "favorable." It can mean changes induced by a third party, redirection of the opposing parties' efforts, revision of their goals, and so on in great complexity. Disciplined study, however, should improve our knowledge of the limits of modification, and perhaps mitigate the unintended consequences of well-intentioned acts.

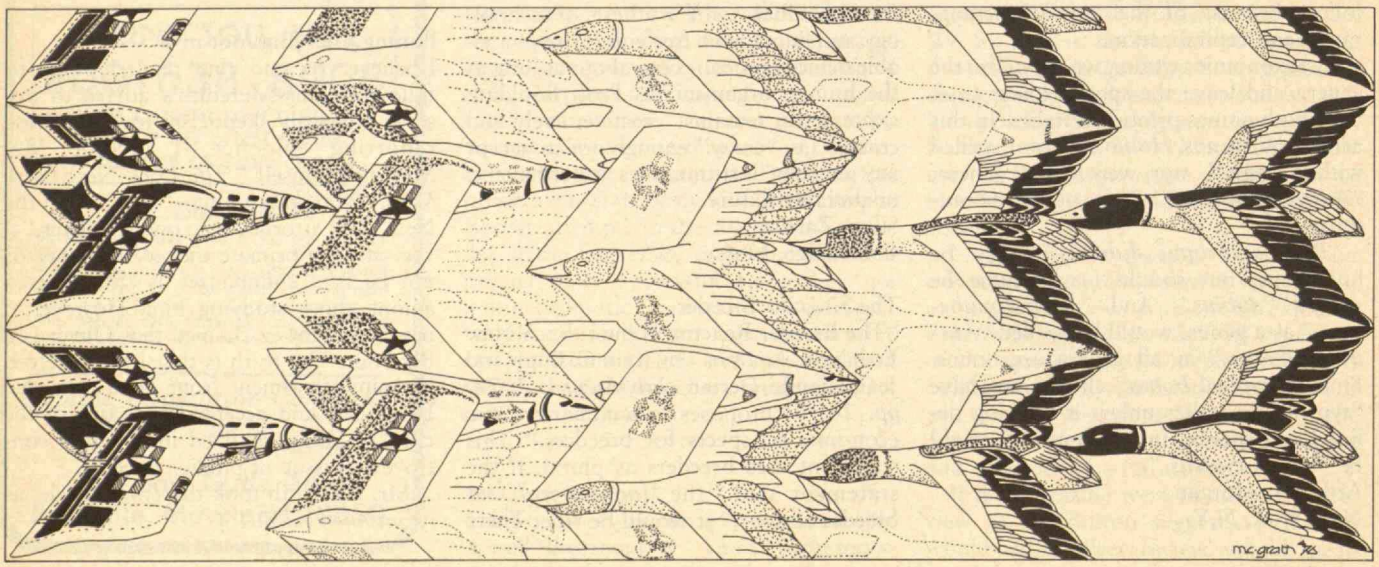
"Redistribution" also demands scrutiny. In economics, the term refers to grants, explicit or implicit: that is, one-way transfers, redistributions of net worth, and so on. We may be concerned with redistributions of threat capability or credibility, whether violent or nonviolent. We may be concerned with redistributions in the "integrative structures" that involve such things as status, legitimacy, community, integrative clusters or "publics," terms of reciprocity, benevolence, or malevolence.

With the concept of "perceived welfare," we are again in the realm of values. The relation of perceived to "actual" welfare is not clear. The words "regret" and "disappointment" suggest that there can be a divergence between perceived and actual welfare. But the identification of actual welfare in some objective sense is very elusive. Perceived welfare dominates behavior.

Swords into Softballs

We cannot always assume that the more we know about a conflict, the better we can manage it. For instance, suppose we could write a "distributional impact statement" which would define who is benefited, who is injured, and who is un-

(Continued on p. 15)



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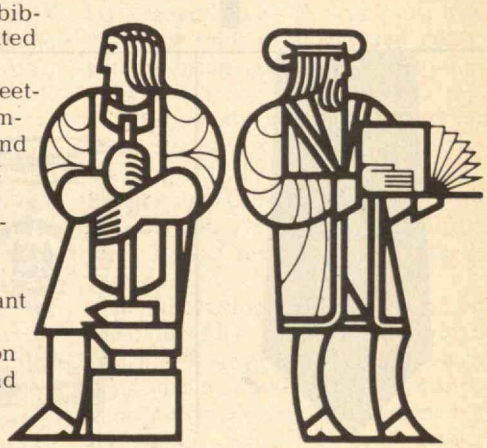

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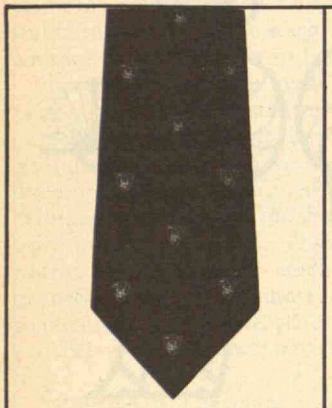

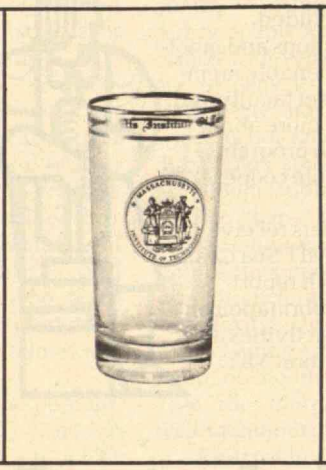

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Nutrition Aid, No Strings Attached

National Report
by
David F. Salisbury

Big Daddy never gives anything for free. So it's not surprising that the industrial nations, including the U.S., have attempted to do far more for developing countries than with them. But in addition to widely documented political corruption, paternalism can also prompt inappropriate advice and the bestowal of technologies ill-suited to the needs and abilities of the recipients.

Fortunately, this attitude is beginning to change, in response to the rhetoric and growing militance of the Third World, and as international foundations and national aid agencies learn from past mistakes.

Science for the People

One of the organizations spearheading the new directions in aid policy is Canada's International Development Research Centre (I.D.R.C.) headquartered in Ottawa. Created five years ago, the Centre parcels out its money primarily to native researchers.

"The old pattern was to hire expatriots with technical training and send them to a country to get the job done," says W. David Hopper, President of I.D.R.C. "It was time to let aid recipients start making their own mistakes, instead of making mistakes for them," he says.

Instead of hiring a large staff of western experts, I.D.R.C. set out with a few experienced people as project directors. They each spend six months out of the year globe-trotting: visiting and advising native researchers on I.D.R.C. grants, building communications "networks" among scientists from developing countries, and looking for new, worthwhile projects to support.

The 60 million Canadian dollars that the Centre has disbursed so far is "untied aid." There are no stipulations on how the native scientists spend the money they receive. The only demands are that the recipients be doing research which has direct bearing on the problems facing the region where they live. "It is not our purpose to support research which leads to papers in scientific journals," says Joseph H. Hulse, Director of I.D.R.C.'s Agriculture, Food, and Nutrition Sciences Division.

As a matter of fact, not all the researchers they fund have formal scientific training. "As long as they are careful workers and are doing research, progressing logically from the known to the unknown, we are willing to support them," says Mr. Hulse.

No "Green Revolutions"

The focus of many of the Centre's efforts has been tropical agriculture, particularly crops and technologies that have been neglected. A good illustration is the work they have supported at the International Centre for Tropical Agriculture (C.I.A.T.) in Colombia.

In its granulated form, cassava is known in the U.S. as tapioca. This starchy root is the staple of between 200 and 300 million people. But before 1971, only one agricultural research center in the world was conducting cassava research. Although the average yield of cassava in Colombia is ten tons per hectare, the higher yielding varieties selected by the Colombian researchers have enabled farmers to achieve up to 45 tons per hectare.

In addition, a wasp has been identified which preys on the horn worm, a persistent cassava pest. C.I.A.T. experimenters have discovered that pesticide sprays will kill off these wasps and bring even greater horn worm infestation.

Researchers at the University of Guelph have developed a laboratory scale model of a low-cost, low-technology fermenter for cassava. Cooked cassava roots are inoculated with a fungus which grows and produces a protein that enriches the mash for use as animal feed. Because cassava is nutritionally poor, livestock grown on the feed could be a valuable source of human protein.

"Training indigenous scientists is essential for the medium- and long-term future," says Hugh Doggett, a British plant breeder with I.D.R.C. stationed in Hyderabad, India. "We can't just walk in with vast sums of money and take over without being more colonial than the colonizers."

When asked whether the Centre favors labor-intensive or capital-intensive approaches, Mr. Hulse replies, "We are not Proctor and Gamble or Lever Brothers. We are not trying to sell anything. We don't have a model of what is best for everyone."

In this business, there are no sudden breakthroughs, no "green revolutions" which will solve the world's food problems quickly. Rather, scientists and politicians must tailor strains developed at international centers to local conditions, and generate a cultural climate that will encourage farmers to adopt new ways in return for greater harvests.

David F. Salisbury is Science Editor for the Christian Science Monitor, *and a regular contributor to* Technology Review.

The policy of "untied aid" is gaining acceptance in nutrition assistance programs for developing countries. One organization, Canada's International Development Research Center, has ceased exporting western technicians. Instead, they make grants, and give aid recipients a chance to make their own mistakes. (Photo: International Development Research Center)

Pacific Follies, or the Ravishing of Hawaii

Hawaii's environment was probably in danger even before the Europeans arrived; some of the birds, for example, were trapped in thousands to furnish the ceremonial robes of Hawaiian kings.

But the serious destruction of habitat began when European mariners released cattle, horses, pigs, and goats to establish a meat supply for future visits. Captain George Vancouver brought cattle to the islands in 1794, and persuaded King Kamehameha to proclaim a ten-year taboo to prevent the common people from hunting them. Cattle and sheep were driven to the Waimea plain, "a great tract of luxuriant vegetation," where they were allowed to roam unrestrained.

As the animals multiplied, they moved steadily into virgin forests, trampling ground cover and browsing on seedlings of native trees. For more than 100 years, non-native mammals, especially cattle, razed the forests. Each year, from 1921 to 1946, 10,000 cattle, goats, and pigs were killed in Hawaii's forests. On Mauna Kea, the last wild cattle and horses were not exterminated until the 1930s, and cattle still remain on other islands.

The most serious problem now is goats. Despite intermittent attempts to control them, some 14,000 goats roamed Volcanoes National Park in 1971. Plans to eliminate goats and sheep from the park have been repeatedly frustrated by pressure from sporting interests, even though hunters represent less than two per cent of Hawaii's population. Dissenting park personnel have been transferred elsewhere.

Many vegetated areas destroyed by grazing animals are unreclaimable; the topsoil has been stripped along with the forest. This encroachment is painfully evident on the upper slopes of Mauna Kea, where a few tree skeletons in a rock-strewn waste attest to a once lush foliage.

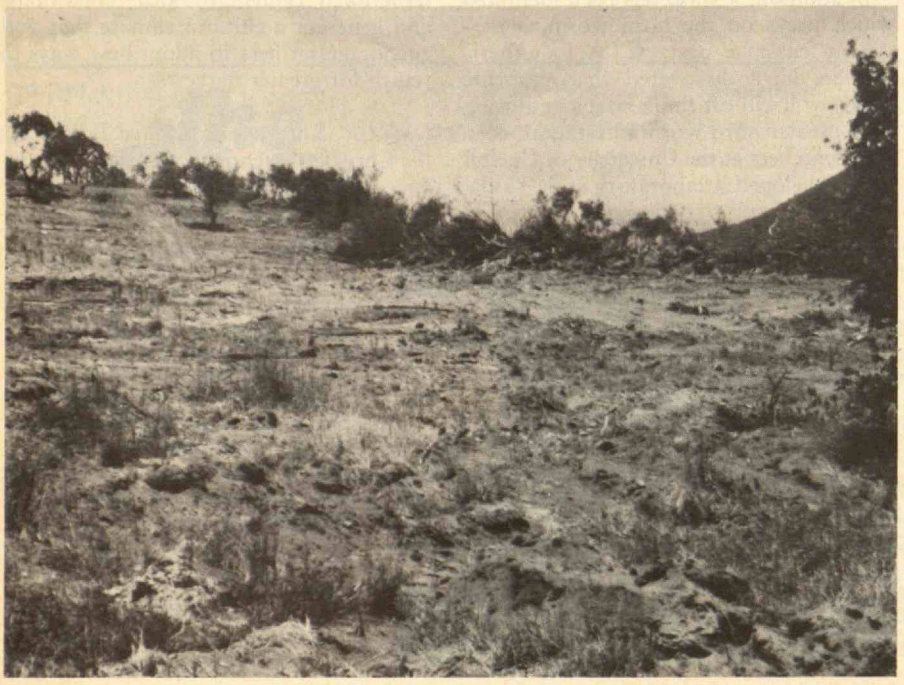
A persistent motive of the island environment's exploitation has been profit. During the early 19th century, the Hawaiian forests were systematically divested of sandalwood for the China trade. Missionaries and seafarers became landowners who set about clearing extensive areas on the main islands, at first for ranching, and later to grow sugar cane and pineapples. Ironically, most efforts to prevent the destruction of the hill forests have not aimed to conserve native vegetation, but to preserve watersheds for lowland irrigation.

Seduced . . .

The destruction of Hawaii's unique flora and fauna has been obvious since the turn of the century. And many biologists and foresters have pleaded for responsible conservation practices. Yet the desecration has continued and, since World War II, has even accelerated. For example:

— In 1957, the state Division of Forestry and the U.S. Forest Service initiated a cooperative agreement to develop a timber industry. More than 46,000 acres — including "forest reserves" — have been cleared of native trees and planted with exotic varieties, many of which do not have even potential commercial value. In 1971, following a request from a senator and the U.S. Forest Service, Congress allocated $414,000 to establish a timber industry based on southern pines, trees unsuited to Hawaiian conditions.

— During 1969 and 1970, the state Division of Fish and Game bulldozed some 400 acres of the last remaining mamani-



Incompetence, ignorance, and insensitivity conspired to level 400 acres of the last mamani-naio forest in Hawaii. The state Division of Fish and Game wanted to introduce pheasant to the islands, and picked this spot to create their habitat. Unfortunately, such mismanagement has been the rule, not the exception, in Hawaii.

Technology/Environment
by
Ian C. T. Nisbet

naio forest in order to create a habitat for introduced pheasants. State agencies have also permitted destruction of forest reserves to provide wood for souvenirs, and bulldozing of tree ferns to provide logs for the orchid industry. The forestry agencies have no programs to replant tree ferns.

— In the 1960s, the forests were further abused by defoliation experiments conducted for the Defense Department. Ordnance impact areas on Oahu have suffered repeated ground fires, and since no fire breaks were made, extensive forest lands and many endangered plants have been lost.

— The Naval Air Station at Midway was troubled in the 1950s by collisions of jet aircraft with albatrosses soaring over the dunes near the runway. Ignoring the advice of biologists to simply level the dunes, the Navy started clubbing the birds in their nests. As predicted, this only worsened the problem by giving the dead birds' mates more time to fly around, so the Navy had to level the dunes anyway. Subsequently, a communications station was built on the island and thousands of albatrosses were killed by flying into its network of guy wires. The station was closed only when it became obsolete, in 1967. Kaula Islet, off Niihau, is an important seabird colony still used by military aircraft as a target.

— In 1955, the state Department of Agriculture began releasing 23 species of carnivorous snails, hoping in vain to control the introduced Giant African snail. Instead, the predators spread into the mountains and have eliminated dozens of species of the unique and colorful Hawaiian land snails that collectors prize.

— According to the state Department of Agriculture, pesticides are far more prevalent in Hawaii than on the U.S. mainland. Local termite exterminators use 500 to 1,000 times the amounts of poisons used in mainland applications; chlordane residues in Hawaiian freshwater fish are the highest in the nation.

. . . and Abandoned

What is distressing in these examples — and many others that could be cited — is that much of the damage being inflicted on Hawaiian wildlife is deliberate. One should not be surprised, perhaps, that the military bureaucracy is indifferent to the natural environment. (But even the desk-bound Navy admirals should have known enough about the superstitions of the sea to think twice before ordering the killing of albatross.)

It is discouraging to find that agriculturists know so little about agriculture, that foresters know so little about forestry, and that game managers and park superintendents know so little about game and parks. The natural environment of Hawaii could be maintained for the public benefit, but it will not be until its managers learn to appreciate the unique environment they are destroying. At present, the actions of state and federal officials reflect a staggering combination of incompetence, ignorance, and insensitivity.

Ian C. T. Nisbet, who writes regularly for Technology Review, *is Associate Director of the Scientific Staff of the Massachusetts Audubon Society.*

O.T.A.: Time to Question

Special Report by George A. W. Boehm

One result of the Interstate Highway Program is that almost every mass transit system in the country has failed or is operating under heavy public subsidy, while fares have continued to skyrocket and while would-be customers have driven automobiles on expensive new highways. Another result is that the gain in employment due to roadbuilding has been more than offset by the loss of jobs in public transportation. And half the population — those who are too young, too old, or too poor to own and drive automobiles — have been deprived of much of their former mobility.

Were these counterproductive effects of the Interstate Highway Program foreseeable? Probably, yes. Had it been in operation in 1952, would the Office of Technology Assessment have advised Congress of them? The question is patently unfair, because even now O.T.A., founded in 1974, has not yet had time to establish itself and tackle assessments of such complex, controversial subjects.

The fact is that O.T.A., founded to help Congress understand the likely consequences of new technologies and programs, has not yet engaged in much controversial study. Now some of O.T.A.'s strong supporters are beginning to wonder when it will begin to attempt extremely complicated assessments and come up with answers that may alienate many people in power, including some influential members of Congress.

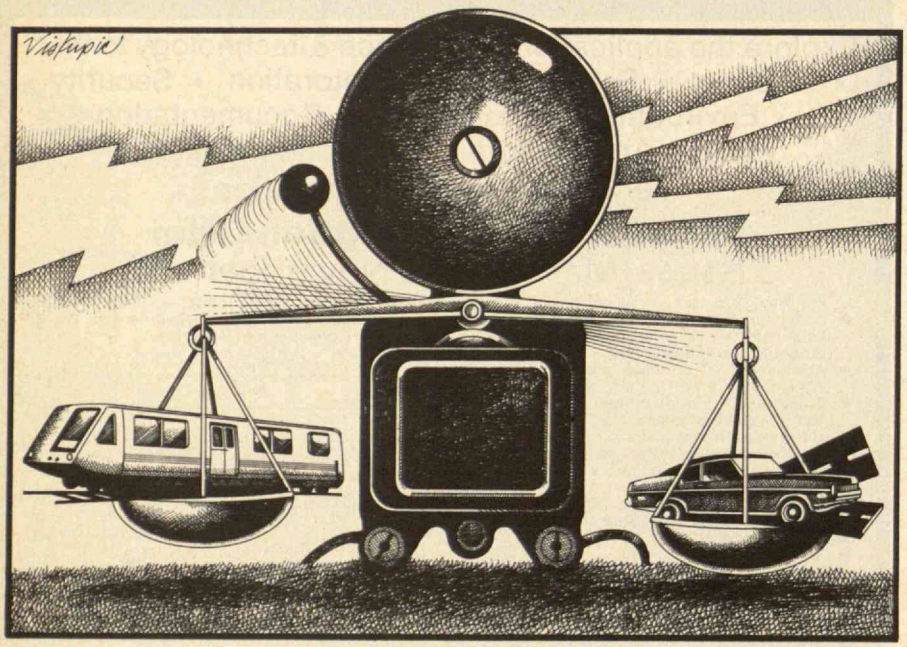
Advice to the Legislator

The first assessment published by O.T.A. is still the only one that has generated any heated debate. That study questioned whether drugs prescribed by generic name were generally inferior to those prescribed by brand name, as major manufacturers have long been maintaining. The panel performed some spot testing and concluded that brand-name drugs are not necessarily more efficacious than their less expensive counterparts sold under generic names. Having found a distressing number of off-quality lots of each type, the panel went a step beyond its mandate and admonished the Food and Drug Administration to tighten its screening requirements for life-or-death medicines.

At this early stage of its life, O.T.A. may necessarily have to avoid bitter controversy. If the agency is to survive so that it can exert real influence later, it must avoid alienating members of Congress until it has their confidence and sympathy. Hence the current (if unstated) policy of O.T.A., presumably set by Emilio Q. Daddario, its director: provide credible answers to questions that Congressmen ask. Mr. Daddario fought hard to bring O.T.A. into existence while he was Chairman of the potent House Science and Astronautics Committee, and he is too wise a politician to court enemies too soon.

One unfortunate result of this policy, however, is that O.T.A. is spending a good deal of time and effort on small projects unworthy of its ambitions. To some extent it is duplicating the work of the Congressional Reference Service of the Library of Congress, which on short notice performs library searches and provides members of Congress with as much thoughtful evaluation as can be had in that way.

By quickly answering specific questions, O.T.A. has helped some members of Congress decide how to vote on imminent legislation. That is a useful function. It helps to make legislative decisions more rational; it demonstrates that O.T.A. is competent and eager to serve the nation; and it wins friends in Congress, some of whom may respond by voting to increase O.T.A.'s pitifully small annual budget of just about $5 million. But such modest services do little to show whether O.T.A. can live up to its original aspirations.



Early Warning

The seeds of O.T.A. were sown about ten years ago in a series of conversations between Jerome B. Wiesner, who is now President of M.I.T., and Mr. Daddario, then a Connecticut congressman. Aware of the rapid rise of public protest against unwanted by-products of technology, Dr. Wiesner suggested that Congress needed a sort of early warning system before it considered sponsoring big technological projects or regulating technological change.

Mr. Daddario developed the idea to make it politically palatable. O.T.A. is strictly non-partisan; its governing board consists of six Senators and six Representatives, half Republicans and half Democrats. It also has a technical advisory council of about a dozen eminent engineers and scientists, all experienced in government dealings.

The policy is never to tell Congress how to vote. If O.T.A. were to attempt to lobby for a controversial position, it would soon be ignored or dismantled. Instead, technology assessments are supposed to present rational analysis of whatever is being considered and to list all major options and their likely consequences. With this kind of expert information in hand, members of Congress and influential congressional staff executives can presumably make their own decisions.

Opening Windows

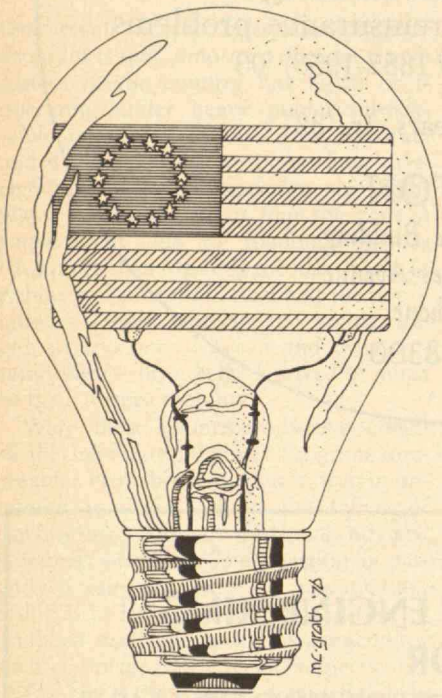
So far, this low-key approach has worked well enough — much better, in most cases, than the usual confusing congressional hearings from which much vital legislation traditionally stems. But since O.T.A. was founded, there have been no emotion-laden battles such as those that occurred when Congress was voting against supersonic transports, antiballistic missiles, and artificial sweeteners.

And O.T.A. has not entered the area of military procurement. What new weaponry is really promising enough to warrant development and manufacture? Can military requirements be satisfied more cheaply and with less duplication? When Congress asked questions of this sort in the past, the Defense Department experts have answered that crucial information is classified, and, anyway, "Papa knows best." A few Congressmen are now expressing the hope that O.T.A. will soon open more windows in the Defense Department.

The day is coming when O.T.A. will have to show that it can do all that it was set up to accomplish. Members of Congress, necessarily most interested in legislation that will come up for consideration within the next year or so, even within the next month, are not likely to ask many questions that lead to long-range technology assessments. O.T.A., through its technical advisory council, will have to ask itself the really big questions — such as what might be involved in setting a national growth policy; and then the Office will have to give some of these assessments priority over the smaller matters with which Congressmen have day-to-day concern.

George A. W. Boehm is a distinguished free-lance science writer and a member of the Advisory Board of Technology Review.

Book Reviews



Science in the New World

Thinkers and Tinkers: Early American Men of Science
by Silvio A. Bedini
New York: Charles Scribner's Sons, 1975; xix + 520 pp., $17.50

Reviewed by John B. Rae

Silvio Bedini is the country's leading authority on early American scientific instruments. Here he demonstrates that he is equally at home with their makers and users.

The book is, by necessity, much more than a comprehensive account of the development of science from the first colonial settlements to the beginning of the 19th century. American science was, for the most part, a transplanted European science. Yet one wonders whether adaptation to the social and environmental differences between the Old World and the New produced a distinct and definable American science — or at least definable American approaches and attitudes toward science. The question holds for American technology, as well, for while Dr. Bedini deals primarily with science and scientists, the problems of procuring adequate instrumentation suggest the level of our technological competence.

A Consuming Curiosity

Colonial America was a raw, new country with an urgent demand for technical skills, but little place or opportunity for the pursuit of scientific knowledge for its own sake. The colonies had no institutional structure such as that which supported science in Europe, no American counterparts to the European universities. Nor was there a wealthy leisure class to produce gentleman scientists such as Robert Boyle. (John Winthrop, Jr., may be counted an exception, although "leisure" scarcely describes his activities.)

Instead, the colonies nurtured people curious about the world around them, but who had to earn a livelihood outside "pure" science — as surveyors, cartographers, compilers of navigational tables and ephemerides for almanacs, and instrument makers. (Benjamin Franklin, ever ambitious, published an entire almanac.) Under the circumstances, it is surprising that so much good scientific work was accomplished: Franklin's electrical research and Rittenhouse's astronomy become all the more impressive.

This pattern of pragmatism in American science persisted even after institutions for teaching and research had been established. It is still manifest in a popular belief that scientific research should be directed toward articulable, utilitarian purposes. Thus, since scientists and engineers, like most other people, do what is likely to win approval and support, American science and technology have been heavily oriented toward applications rather than toward academic discovery.

Art and Artifact

The result has been in many ways beneficial. If less attention has been paid to basic research in America than in Europe, it could also be argued that as much new knowledge has come from applied research as from basic and that the distinction between the two is largely artificial, even invidious. (Pasteur offers a striking example; his work on microorganisms stemmed from an effort to improve French beer.) Moreover, the pressure on American scientists to justify their popular support has probably tended to keep them more closely in the cultural mainstream than their European colleagues. In any case, even during the 19th century when pragmatism presumably reached its height, a good deal of basic research was conducted. The quantity and quality may not have matched the work then going on in Europe, but a society which produced Joseph Henry, Asa Gray, A. A. Michelson, and Willard Gibbs was not completely neglecting pure science — even though Michelson's Nobel Prize, America's first, rewarded a technical skill (measuring the velocity of light) rather than an original discovery.

Although colonial craftsmen showed a ready adaptability and steady sophistication, the best instrumentation, most significant discoveries, and most brilliant practitioners were principally European. I am particularly intrigued by an order that Benjamin Franklin sent to London in 1752 for "a pair of Mrs. Senex's improved globes." Who was Mrs. Senex? If there was a woman instrument maker 200 years ago, it would be nice to know about her.

The colonial instrument makers did their best work with wood, a characteristic of much of American technology until well into the 19th century, that marked a realistic adaptation to local conditions and available materials. And the colonials developed a flair for ornamentation into an art, with the embellishment of compass roses as its best-known expression. The craftsmen showed originality, and their practice appears to support Cyril Smith's thesis that much useful technology originates in an aesthetic milieu.

John B. Rae is Professor of the History of Technology at Harvey Mudd College; he has written numerous books on the impact of the automobile on society.

Pedal Pushers

Bicycling Science
Frank Rowland Whitt and David Gordon Wilson
Cambridge: M.I.T. Press, 1974; xiii + 247 pp., $12.95

Reviewed by Edward Wheeler

At walking pace, a horse is rather more efficient than a human pedestrian, in terms of power used per unit of gross weight moved, at a given speed. On the other hand, people are far more efficient than rabbits; it seems traveling by leaps and bounds is a wasteful way to progress. The system of upright levers upon which we perambulate is among the best solutions to the problem of locomotion that nature has ever devised.

But nature did not invent the wheel (unless you count Rotifera, which are not land-dwelling). An automobile, at a few kilometres per hour, is about twice as efficient (in the sense defined) as the horse, and a man on a good bicycle is three times again as efficient; a factor of ten better than walking. At running speeds, cycling beats footslogging by a factor of five. Above 20 miles per hour, however, air drag pulls the cyclist's efficiency below that of an automobile. (Attempts have been made to fit bicycles with streamlined shells, but to little effect.)

All these facts are drawn from a few pages of *Bicycling Science.*

Improving on Nature

One could argue that the bicycle is one of the great inventions of all time, in the same class with the windmill, the bow-and-arrow, and the magnetic compass. It is too early to be sure. The bicycle as we know it, complete with pedal-and-chain rear-wheel drive, has been around for only 90 years. In a world of jet airliners and 2000 megawatt generating stations, it looks prosaic and inconsequential. Histories of technology tend to give it a couple of paragraphs.

Yet, the bicycle stands out among the products of our civilization in two ways, probably related. First, it is one of the very few authentic improvements upon nature, as we have seen. Second, it is one of the very few examples of successful technology transfer to poor countries: the bicycle and its load-carrying variants provide ordinary people with something genuinely useful at a price they can just about afford.

Some kind of bicycle ought to survive our culture's decline and fall; *Bicycling Science* gives hope that it might. The book pays considerable attention to design alternatives which even a lifelong conventional cyclist might never have thought of. Acceptable frames and rims, we learn, can be made of wood; plain bearings (as opposed to ball bearings) have not only been tolerated by children in the past but have actually been considered for adult use in recent years. If the craftsmen of a nonindustrialized future ever abandon the bicycle as too difficult, it will perhaps be the chain that beats them.

The Human Wheel

If we view the man-on-a-bicycle as a single being (*Homo rotiferus*) evolved from an earlier species which had the fortunate combination of long legs and a large brain, *Bicycling Science* becomes an account of the physiology of this species, in some of its many varieties, with particular attention to the organs of locomotion. I put it this way because the book, subtitled *Ergonomics and Mechanics*, is closer in spirit to descriptive and analytical science than to applicable engineering. Varieties bred in captivity, such as the recumbent and hand-propelled types, are described in detail, to the neglect of the hardier wild forms.

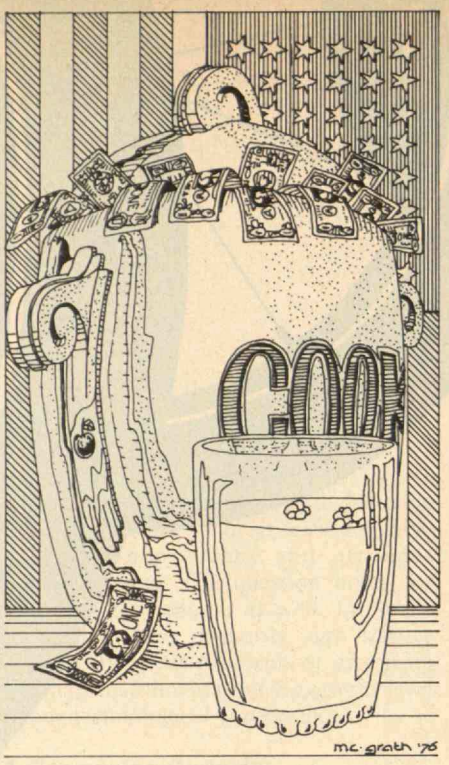
This somewhat specialized perspective leads the authors to some strange conclusions. Maintenance, for example, is listed among the bicycle's disadvantages — "attuned to the low-labor-cost conditions of an earlier age." *Homo rotiferus,* in his natural state, simply learns during childhood how to dismantle and reassemble his nether extremities, using a tool-kit that can be held in one hand. The question of labor costs rarely arises: indeed, this is one of the bicycle's principal advantages over the modern car.

Another shortcoming cited is that "it is difficult to carry packages, briefcases, shopping-bags, etc. conveniently or safely." Not so. Successful adaptations, structural and behavioral, have been with us for decades. *Homo rotiferus Netherlandii* is able routinely to carry two full-grown *sapiens* (one on the cross-bar, one over the back wheel) for a distance of several kilometres, all three of them drunk. The fearsome *Homo rotiferus rufus,* a southeast Asian variety, carries sufficient weaponry to compete successfully with much larger contenders for his hilly habitat. Beyond these are the three-wheeled types, such as the tropical Trishaw and the almost ubiquitous Vendor, whose highly developed load-transporting abili-

ties have enabled them to enter into symbiosis with the weaker, nonpedaling *sapiens*.

In this latter area, ergonomics might conceivably be valuable; it is possible that goods and passenger cycles are not yet fully evolved. But the standard "touring" bicycle (domesticated for urban commuting and shopping) probably is, and I am far less hopeful than Messrs. Whitt and Wilson seem to be that N.A.S.A., General Motors, or anyone else could at this date improve it substantially. (The end-point of the evolution of any system is characterized by optimization — not by complete immunity to all the natural shocks.) As Robert Frost says in his poem about a monkey with a magnifying glass, it's knowing what to do with things that counts.

Edward Wheeler is Executive Editor of Search, *the journal of the Australian and New Zealand Association for the Advancement of Science, and former Managing Editor of* Technology Review. *An avid cyclist, he reports that Sydney motorists are slowly adjusting to bikes on the road.*



Laying Claim to the Human Condition

Legal Aspects of the International Transfer of Technology to Developing Countries
Charles Chukwuma Okolie
New York: Praeger, 1975; xiii + 187 pp., $15

Reviewed by Stephen J. Kobrin

Poor countries are seeking a new international economic order that could require redistribution of the world's wealth through such mechanisms as trade preferences, commodity agreements, and direct aid. But redistribution requires more than the passive acquiescence of the rich countries; it requires their active — even enthusiastic — participation. Yet, unless real growth rates are substantial, a transfer of resources augurs a substantial sacrifice in standard of living for the citizens of the richer countries.

There has been difficulty in finding compelling, politically convincing reasons why rich countries should aid poor. Justifications for development assistance have tended to be vague and have failed to motivate legislators and voters to approve a significant transfer of resources.

Of course, poor nations have not faced the same difficulty in justifying aid. They see their own underdevelopment and the development of the West as one process: their relative poverty is a result of past and present exploitation by the industrialized countries. Not surprisingly, Western discussions of aid have taken a different tack. *Partners in Development,* a report sponsored by the Commission on International Development published in 1969, suggested that we adopt an attitude of enlightened self interest, acknowledging the promise of increased world purchasing power, balanced with the threat to security posed by a very poor majority on an ever-shrinking planet. However, neither contingency appeared immediate enough to be really compelling, and so the report noted that the simplest argument is the moral one: ". . . it is only right for those who have to share with those who have not."

In *Legal Aspects of the International Transfer of Technology to Developing Countries,* Charles Chukwuma Okolie, who holds law degrees from both Kiev and Berkeley, searches for a legal obligation of rich to poor nations. He recommends developing "law norm formulations for development relationship problems among nations," proposing the doctrine of estoppel — maintaining consistency with prior commitments — and a general principle of economic welfare. Under the estoppel doctrine, pledges of rich governments (through their authorized spokesmen) to provide aid or preferences may be enforceable. The principle of welfare would extend elements of municipal laws, which provide for redistribution of income and/or wealth to developing countries. (Mr. Okolie notes that most of the advanced countries, capitalist and socialist, explicitly provide for such domestic transfers.)

Looking to international law as a basis for compelling development aid raises as many questions as it answers. One is left with little more than a moral argument. Given the absence of a world government, how is a judgment to be enforced upon a rich country? Furthermore, national commitments are often made for a specific period of time. And perhaps most important, it is difficult to see how international law norms might motivate popular sacrifice.

Gunnar Myrdal observed that the postwar spurt of interest in development was not ". . . an autonomous and spontaneous development of social science," but a result of political changes: the breakup of colonial empires coupled with cold war polarization. U.S. policy with regard to international resource transfers has always been pragmatic. As Mr. Okolie notes, the Truman Doctrine and the Marshall Plan saw aid as an economic and military response to the "Soviet threat," as a means to increase security. It is clear that the extension of aid to poorer countries was motivated, or at least sold to Congress and the public, as a means for keeping the developing countries out of the communist orbit and solidly in the U.S. camp. And the stimulus to U.S. business provided by the requirement that a percentage, or perhaps all, of the funds transferred be spent in the donor country also served to justify assistance programs.

There have been problems. We have found that development of relatively traditional societies requires a good deal more than a transfer to resources, and many of the poorer countries have had the bad manners to show their independence. The result was predictable: it became increasingly difficult to justify aid (or even preferences) for countries that failed to show proper appreciation.

A Universal Social Solvent

Recent events may be adding immediacy to the threat of global unrest posed by the gap between rich and poor. On November 10, 1975, the United Nations General Assembly declared Zionism a form of racism. With some exceptions, the resolution was supported by the poor countries and the socialist bloc and opposed by the advanced capitalist nations. While several straightforward explanations for the vote have been suggested, such as the oil-related power of the Arab states and anti-Semitism, one senses a deeper source for the anti-Israeli feeling common in the Third World.

Much of the antagonism may flow from the fact that the establishment of the Jewish homeland was in part a function of colonial power relationships. Still more important, Israel is a Western state physically located in the Third World. Israel is the West's most vulnerable outpost, serving as a focus for the rage of the generally ex-colonial poor nations against the rich.

While it is not clear that the resolution will have any immediate effects upon Israel, it may well compromise the U.N. The

very strong anti-Western sentiment of the Third World countries makes any consensus difficult. While many of the poorer countries lack individual economic and political power, as a group they can disrupt international relationships. In an increasingly interdependent world, where it is virtually impossible to isolate conflict, Third World unity does pose a real and immediate threat to global security.

Through both colonial rule and whatever transfer of resources has already taken place, traditional patterns of life have been disrupted in many of the developing countries. Aid missions and investment by multinational corporations foster an intercultural transfer that superimposes the institutions of industrialization upon traditional social structures. Industrialization has no neutral consequences; it serves as a universal social solvent, breaking down traditional relationships and welfare mechanisms. And as Third World cultures begin to reintegrate consistent with widespread industrialization, they require time and resources which often cannot be supplied indigenously.

Encouraging the initiation of this irreversible process without helping to facilitate its completion is, in Jean-Paul Sartre's words, "laying claim to and denying the human condition at the same time." As he points out, the contradiction is explosive.

Perhaps the problems of the U.N. are tangible evidence that the large and expanding gap in resources between rich and poor nations is a real, present and direct threat to world security. I do not suggest that the richer nations "buy off" the rage of the poor. Rather, recent events indicate the danger in failing to allow for a transfer of resources needed for development.

Stephen J. Kobrin is Assistant Professor of Management, in International Management, at M.I.T. He is currently studying the effects of foreign investment in social change, the relationship between flows of foreign investment and political instability, and the importance of nationalism in the adverse reaction to inward flows of foreign investment in the U.S.

Letters

Continued from p. 3

it applied to me, at face value and went on to allege that Dr. Rines was defamed by appearing in the same paragraph with me. Obviously, Mr. Meredith checked only half his story, and for the remainder relied on source material from a periodical using questionable tactics to generate false sensationalism.

Michael Miller
New York, N.Y.

Touché! Our apologies for assuming that Mr. Miller thinks Oliver a Big Foot. We relied on several accounts of the affair, not just Time*'s, all of which inferred Mr. Miller's belief. — D.M.*

The Nitinol Engine, Returned

I was delighted to find my sketch of an early continuous nitinol engine copied in your December issue (*"The Stretch for New Energy," pp. 19-21*). But I am keenly disappointed that the operating principle is described incorrectly. The engine cannot function as you describe it.

What makes nitinol interesting in this type of engine is the fact that a belt can be made which elongates when cooled and contracts when heated — the opposite of what one might expect. The phase change which makes this possible stores a lot of energy, too: about a joule per gram per cycle. This is at least two orders of magnitude more than the joule effect utilized in rubber band engines. Your description implies that ordinary thermal expansion and contraction are involved, which would not develop sufficient power density to be interesting.

Nitinol is really something different. Recent engines, with nitinol wire in tension replacing the helix, develop more than a watt per gram and run at shaft speeds in excess of 1,000 r.p.m.

A. D. Johnson
Berkeley, Calif.

Boulding

Continued from p. 4

affected by some act or decision. The result might be surprising. And if believed, it might actually exacerbate conflict.

The role of ideologies of conflict is very important, for what we perceive our welfare to be is in part a function of them. Dialectical ideologies, whether nationalist or socialist, exacerbate conflict unless they become ritualized as in sport. While sport is not quite the surrogate of war that William James hoped it might become, it is a fascinating example of ritualized conflict in which who wins does not really matter (if it did, we would poison our opponent's beer). Yet we have to pretend intensely that the winner does matter. It is a strange paradox that if it ever did really matter who wins, or if we did not care who wins, we could not engage in sport.

Perhaps one of our most pressing needs at the moment is to find a ritual equivalent of war, and to make sport of politics.

Kenneth E. Boulding is Professor of Economics and Director of the Institute of Behavioral Science at the University of Colorado. He writes regularly for Technology Review.

Trend of Affairs

Trends This Month

CANCER 16

Arguments over environmental cancer . . . and speculation on the role of viruses in causing cancer

FOOD 19

Breast feeding slips into fashion . . . agrotechnology falls out of favor . . . carbohydrates push over protein . . . and city folk grow their own

ENVIRONMENT 21

Concern over indoor air . . . and over New York City's effect on the Northeast

ENERGY 22

Plasma theory is found to be at odds with fact

ASTROPHYSICS 23

A computer-simulated universe exhibits no superclusters

TELEPHONE CENTENNIAL 24

The little phone that wasn't there . . . computers beyond the awkward age

CANCER

Prudence, Profit, and Cancer: A Fierce Tug of War

Ignorance about the cause and progress of cancer overbalances knowledge. This ignorance makes any legislation difficult to pass, and any prevention program hard to put into practice.

But lines have been drawn, and industrial spokespersons oppose environmentalists and public health workers, and the two sides cannot agree even on basic facts.

Two such adversaries are Samuel Epstein, Professor of Environmental Medicine at Case Western Reserve Medical School, and Roger E. Drexel, Vice President, Biochemistry Department at DuPont. Their papers, presented to the American Association for the Advancement of Science and M.I.T. respectively, illustrate the problem:

— On cancer death rates: "Cancer deaths for men are declining, when you exclude lung cancer," says Dr. Drexel. But, according to Dr. Epstein, "the rate of recent increase of cancer deaths is more rapid than the rate of increase in population."

— On occupationally related cancer: Says Dr. Drexel, "Occupational factors form a relatively small portion of all cancers (less than one per cent)." But Dr. Epstein says that "approximately ten per cent of all current cancer deaths in males are occupational in origin."

— On sources of carcinogens: Dr. Drexel: "Cigarette smoking and diet are major causes of cancer, and chemicals are a relatively minor cause." Dr. Epstein: "The majority of human cancers are due to chemical carcinogens in the environment which include chemicals in foods and cigarette smoke and hence are ultimately preventable. . . . 70 to 90 per cent of human cancers are environmentally induced."

While these statistics reflect each interest group's particular point of view, none are in essence false. One group leans toward the side of prudence; the other keeps an eye on profit.

The most volatile area of disagreement has been in the very definition of carcinogen, a crucial factor in determining legislation. The arguments converge on these questions:

— Should the tendency to induce tumors be sufficient evidence for a substance to be classified as a possible carcinogen, and thus regulated?

Says industry, all cancers are tumors, but the converse does not necessarily hold true. Medical textbooks agree that the two terms are not synonymous.

Say environmentalists, while distinguishing between benign and malignant tumors is easy, predicting which tumors will become cancerous and when is as yet impossible. Indeed, there are indications that all cancers begin as innocuous tumors. In addition, a tumor, cancerous or not, is an unnatural growth able to cause death (in the brain, for example, when the growth of a tumor interferes with blood circulation). Tumerogenicity in a chemical is definitely not an indication of safety.

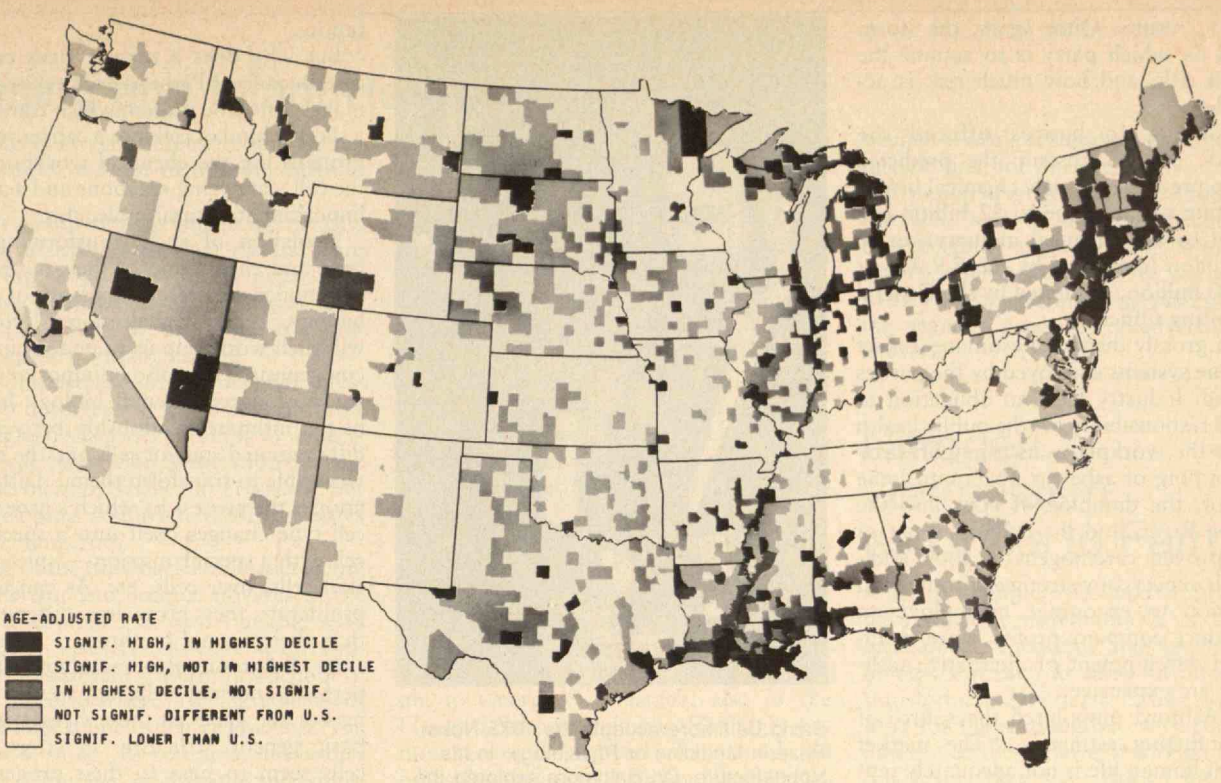
— Can the results of experiments on mice and rats be extrapolated to man?

Industry says that rodents bred for the laboratory are too sensitive to have predictive value for humans. It also argues that any demonstration of cancer hazard for humans should be drawn primarily from reliable human experience, rather than test animals.

Environmentalists argue that most carcinogens are not species specific and that in fact no carcinogen tested thus far has been effective on mice and not humans. In addition, they point out the years of study before the connection between smoking and lung cancer was proven. They prefer not to expose us to potential carcinogens while another such "human experiment" is conducted.

— Is there a safe level of exposure to a carcinogen?

Industry argues that safe levels of ex-



Excessively high rates of cancer (mouth and throat, esophagus, colon, rectum, larynx, and bladder) are found in the industrialized northeast. Except for colon and rectal cancer, which occurs across the population, the high rates in this area of the country are limited to males. This suggests that cancer is occupationally related. For example, bladder cancer is excessively high in New Jersey, where many men are chemical workers. (Source: *Atlas of Cancer Mortality for U.S. Counties: 1950-1969,* National Cancer Institute, DHEW Publication No. (NIH) 75-780)

posure to carcinogens can be established, pointing out that cancer frequency in laboratory experiments has been shown to be dose-related. The human body has great capacity to tolerate or excrete small doses of harmful substances, it says.

On the other hand, no dose has been proven safe, environmentalists say. Cancer can manifest itself 20 years after even a minute exposure. And levels of exposure do not affect the population uniformly, they say. Small children and pregnant women and their offspring are particularly susceptible to carcinogenic poisons — a "minimum dose" acceptable to these groups would be practically zero, some researchers claim.

Most researchers color their opinions in shades of gray, too aware of the absence of absolutes in so misunderstood a field. Thus the question travels from the laboratories to the lawmakers, full of obscurity and with a sheaf of evidence applicable to any side of an issue.

"Waiting for the Bodies to Fall"

Both the World Health Organization and officials of the National Cancer Institute attribute up to 90 per cent of human cancers to environmental causes. Unfortunate New Jersey, the chemical capital of the U.S., is also the cancer capital, with 19 of its 21 counties ranking in the top ten per cent of all counties in the nation in cancer deaths. "There is little doubt that many diseases considered spontaneous, particularly cancer, are caused by environmental pollutants," says Dr. Epstein.

Dr. Epstein, who wrote the original draft of the Toxic Substances Control Act five years ago, has watched it bounce between House and Senate ever since. He simplified the central concept of the legislation for the A.A.A.S.: "Before you introduce substances into the environment, test to make sure they don't harm the environment or humans." Such legislation is long overdue, agreed environmentalist Barry Commoner. It is time for research facts to intervene in private production decisions, he told the A.A.A.S. Cancer research should begin in the factory — before the cancer is produced.

But simplicity vanishes where money is concerned, and chemical industries are fighting to preserve what they see as their constitutional right to free enterprise. The industries are aware that the act, the most far-reaching legislation the E.P.A. will ever be involved with, will cover everything from cosmetics to chicken feed.

The Senate Commerce Committee is now examining the act line by line, tripping on issues that range from who is to repurchase condemned stock, to the number of days between notice of a product's introduction and notice of its examination by the E.P.A.

There are some areas of compromise. According to one E.P.A. pharmacologist, Monsanto is very eager to be rid of the proven carcinogenic PCBs. And the E.P.A. itself encourages economic impact statements on the effects of their proposals, said the same official.

One of the most contested provisions of the bill places the burden of proving "no risk" upon the manufacturer. Manufacturers would much prefer to have the government prove that a substance *is* carcinogenic after it has been introduced. That policy, the one in effect by default at this moment, is reminiscent of the early days of F.D.A. testing of food additives. Then (in 1906) an animal would be fed a substance and allowed to rest for a few days. If the animal lived, the chemical was regarded as safe. Nicholas Ashford, M.I.T. researcher and occupational safety expert, calls this approach "waiting for the bodies to fall."

Who Needs Astroturf?

One "fact" about cancer is accepted by all parties. The testing (and presumably the clean-up or outlawing) of new and already-on-the-market chemicals will be costly. Thus cost/benefit analyses have been applied, with predictable disagree-

ments in results. Once again, the storm centers on which party is to assume the relevant risk, and how much risk is acceptable.

According to figures offered the A.A.A.S. by Dr. Epstein, the predicted costs to pre-test each new chemical before marketing would come to $2 billion (estimated by the chemical industry), or to $80 million (estimated by the E.P.A.), or to $150 million (estimated by the General Accounting Office).

Such grossly disparate estimates reflect the value systems employed by the parties involved. Industry feels no obligation to assume responsibility for the public health outside the workplace (as exemplified by the dumping of asbestos fibers into Lake Superior, the dumping of PCBs into the Hudson River, and the continued use of other proven carcinogens as food additives). It expects any strong environmental regulation to encourage unemployment and reduce company profits, since clean-up and development of alternative technology are expensive.

Dr. Ashford pinpointed the source of the conflicting estimates. "The market value of human life is not adequately represented in traditional measures of lost wages," he said. Benefit/risk analyses measure only economic efficiency, and a trade-off between the risk of harm to workers for the benefit of lower prices on the market place is no deal. The issues of who pays the costs and who reaps the benefits also involve the legal and social goal of individual justice," he said, "though this goal may conflict with economic efficiency."

Barry Commoner told the A.A.A.S. that, as far as he's concerned, cost/benefit analyses are "economic blackmail."

"When fooling with a carcinogen upsets an entire industry, the question to ask is do we need that industry after all?" he said. He thinks manufacture should be limited to those chemicals whose use is irreplaceable. Vinyl chloride, a proven carcinogen, is an obvious example of a substance whose use is, on the whole, an unnecessary hazard. "Do we really need astroturf?" — *S.J.N.*

A Nobel Laureate Ponders Cancer

"A virologist is among the luckiest of biologists. He can see inside his chosen pet, down to the details of all its molecules."

Thus David Baltimore of M.I.T. began his Nobel lecture in Stockholm last December, a speech containing some bold speculation on the role of viruses in cancer.

Dr. Baltimore was co-recipient of the 1975 Prize in Medicine or Physiology with Drs. Howard Temin of the University of Wisconsin and Renato Dulbecco of the Imperial Cancer Fund, London.

David Baltimore accepts the 1975 Nobel Prize in Medicine or Physiology. In his Nobel lecture, Dr. Baltimore explored the theories of why cancer-causing viruses might be allowed to make their homes in living cells.

Dr. Baltimore, his co-recipients Howard Temin and Renato Dulbecco, and hundreds of other scientists, have already discovered much about their virus "pets" — what kinds of genetic blueprints they carry into an infected cell, and the enzymatic baggage they carry with them to ensure the molecular reproduction necessary to their survival. But mysteries remain, both concerning viruses' specific mechanisms of reproduction, and, most important, how these viruses or their products damage infected cells.

Drs. Baltimore and Temin were honored for their discoveries of an enzyme, reverse transcriptase; so named because it reverses the normal flow of genetic information. In almost all living organisms DNA is the basic genetic blueprint of the cell, and from it are copied RNA instructions which oversee the construction and operation of life's mechanisms. However, some RNA viruses use an RNA template to create DNA inside an infected cell. Only these "retroviruses," which operate in such a reverse manner, are known to cause cancer, and in his Nobel lecture, Baltimore speculated on their powers.

The DNA on which these retroviruses base their lifestyles in an infected cell stabilizes the relationship between the virus and its victim cell. It is this stability that allows the virus, unlike its other cousins, to change permanently the growth properties of the cell, said Dr. Baltimore.

But why does a certain virus cause a certain cancer? Perhaps each type of virus makes a specific protein which transforms a specific kind of cell into a cancerous one. Proteins are the chemical workhorses of the cell, catalyzing reactions and acting as important structural molecules.

"Isolation of such transforming proteins and elucidation of their mechanism of action is the present challenge of cancer biology," said Dr. Baltimore. "Not only will such work help us to understand carcinogenesis, it may also be important to the study of developmental biology because of the intimate relationship between the differentiated state of cells and the type of virus able to transform them." Differentiation is the process by which a generalized cell type changes itself into a specialized cell with a specific mission — spleen cells, skin cells, liver cells, etc. As cancer cells proliferate they grow less differentiated than their normal brethren.

Dr. Baltimore also speculated on why perfectly normal cells apparently could harbor the genes of these viruses in their basic genetic structure. In effect, these cells seem to pass to their progeny the seeds of their own destruction, as well as the normal instructions necessary for survival.

Dr. Temin believes that these insinuated viral genes are a normal, important part of a "victim" cell's genes. They are as much a part of the host cell as of the virus. Others believe that the viral genes are inherited because of some infection of the cell's ancestors by the virus, but that they still play some role in the cell's functioning. So, natural selection demands that they remain a part of the cell's genes.

Dr. Baltimore believes that the viruses *are* inherited but doubts any positive role for the virus in a cell's survival. Normally, such silent genes would disappear from a cell's genes, because the inevitable Mixmaster of mutation would tear them apart and discard them. The "victim" cells could survive without the virus gene so nature could discard them.

However, says Dr. Baltimore, the viral cells could escape this fate if they periodically popped out of the cell's genes, reproduced themselves enough times to weed out damaging mutations, and then settled comfortably back into the host genes, silently riding on the cell's genetic coattails. "This is a very sheltered environment in which they live," he said. "Only mutation interferes with the continual transmission of the virus to the progeny of an animal that is infected in its germ cells.

"In this context, the ability of some retroviruses to cause cancer is a gratuitous one, but it is today the most challenging and important attribute of these retroviruses and the one that will dominate future research efforts in this area."

If Dr. Baltimore is right it is certainly Nature's cruelest irony that cancer is one of her afterthoughts. — *D.M.*

Nursing and Infant Health

Like the midi-skirt, breastfeeding in the U.S. goes in and out of fashion with the seasons.

Even as nutritionists lament the breast's disuse, subscribers to the "natural" are endowing lactation with new glamor. In any case, Madison Avenue, at least indirectly, continues to determine the preferred mode of infant feeding.

The importance of commercial pressures to bottlefeed in the U.S. is unfortunate, agreed scientists speaking at a meeting of the American Association for the Advancement of Science in February. But in developing countries, those pressures may be dangerous.

Some of the drawbacks of bottlefeeding are inherent, and become obvious in the simplest comparison with nursing, says Paul Fleiss, research associate at the University of Southern California's School of Public Health. There are ingredients of human milk found nowhere else, not even in cow's milk. It contains antibodies against a number of infantile infections, and alone provides all nutrients essential to the baby's first four to six months in life. No formula can duplicate it; mother's milk is so specific that nursing infants grow only one type of intestinal bacteria. Bottlefed infants, on the other hand, grow a number of potentially pathogenic intestinal bacteria.

Mr. Fleiss says bottlefeeding can be psychologically damaging, as well. "When the mother breastfeeds, she inevitably holds the child, talks to it, pets it. I have pictures of bottlefeeding mothers sitting by the infant's crib reading a book. No attention need be paid the child."

Furthermore, bottlefed babies are apparently more likely to become fat grown-ups. Formulas contain ten per cent more calories than mother's milk. And bottlefeeding mothers are likely to encourage the baby to finish that last drop, whereas a nursing mother will simply withdraw her breast when the child signals he's finished. Data show that chubby babies grow more abundant fat cells that can become still larger with age, making weight loss all the more difficult to accomplish. Hence, overweight adults.

Given all these disadvantages, and the fact that formulas are expensive, why bottlefeed? "If anything, it's less work to nurse," says Mr. Fleiss. "Bottlefeeding requires two hands, nursing only one."

But whose hands? If Daddy, Auntie, or Sister Sue can give the baby its bottle, Mother can go to work. And when the bottle is sufficiently sterilized and the formula correctly prepared, no very serious harm is likely to result.

In developing countries, such precautions are perhaps more the exception than the rule, however. Joe Wray, Professor at Harvard University's School of Public Health, sees the world decline in breastfeeding tied to growing urbanization and poverty. Poor mothers, forced to work, have little choice in the matter of breastfeeding. At the same time, advertising glorifies the formula as an achievement of western science. Yet the poor typically can't satisfy the conditions of sterility and accurate preparation bottlefeeding demands. And formulas are so costly that they are often diluted to the point of nutritional inadequacy. As a result, "in many nations, the infant that is not breastfed simply will not survive," Dr. Wray observes.

With higher infant mortality among non-nursing Third World mothers is a higher birth rate. Since lactation may prolong sterility, non-nursing mothers are more likely to become pregnant soon after delivery than their nursing sisters. According to George S. Masnick, also of the Harvard School of Public Health, "It is now generally agreed that trends in breastfeeding have a profound effect on birth rates."

The only country where both social and economic constraints on infant feeding have been erased is China, according to Dr. Wray. There, government propaganda actively promotes breastfeeding. Mothers who work in factories are given breaks during the day to breastfeed their babies. And on communal farms, women's work schedules are adjusted to include time for nursing.

If similar arrangements were adopted in the U.S. and in developing countries, breastfeeding might become a more attractive alternative, easier for women who work to manage, and less susceptible to the negative pressures of advertising. — *D.McG.*

"Breastfeed; don't bottlefeed." As developing countries grow less susceptible to Western merchandising, infant feeding becomes more a matter of health than glamor. This poster uses Madison Avenue techniques to serve the public interest. (Poster photograph: U.S. Agency for International Development)

Nitrogen, Germplasm as Limits to Farming

America's uniquely productive agriculture has resulted from remarkable advances in mechanical, chemical, and genetic technology. But even as these advances have transformed American farms, provided food for the starving on every continent, and tipped the balance of foreign trade in our favor, they have drawn heavily on non-replenishable resources. Now agricultural scientists are beginning to urge humility — and concern — to temper our confidence in the future strength of American agribusiness.

The concern focuses on two completely different but equally essential inputs to modern agriculture: nitrogen and germplasm.

Cornfields as Fuel Dumps

During the first 200 years of American farming, while farmers diligently recycled animal waste and rotated legumes with grains and grasses, the nitrogen and organic matter in U.S. agricultural soils declined about 40 per cent. In less than 200 years farmers withdrew almost half of the nitrogen that had accumulated over tens of thousands of years through native plants and atmospheric processes, says Samuel R. Aldrich, Assistant Director of the Agricultural Experiment Station at the University of Illinois (Urbana).

Then came a revolution in chemical technology — a dramatic improvement in the technology for manufacturing, delivering, and applying fertilizer. One bushel of corn bought three pounds of nitrogen fertilizer in 1910 but nearly 20 pounds in 1970, and farmers found nitrogen fertilizer cheaper than home-grown. Now our whole agricultural system depends upon generous supplies of nitrogen fertilizer.

The extent of this dependence is made clear by Professor Aldrich's colleague, Professor C. Robert Taylor. If only 50 pounds per acre of nitrogen fertilizer were available in the Corn Belt each year (the current rate of use averages about 125 pounds per acre), corn prices would rise 46 per cent, oats 17 per cent, and soy-

beans 16 per cent. The additional cost of all food produced in the Corn Belt would be $5.3 billion.

Nitrogen is hardly a scarce resource: it is a major component of the atmosphere, in which the supply is almost infinite, and nitrogen removed from the atmosphere for fertilizer is recycled by natural processes. But the manufacture of nitrogen fertilizer is energy-intensive, and it is most economically done by natural gas. Almost to the extent that our immensely efficient agriculture is dependent on nitrogen fertilizer, it is now dependent on natural gas; and the latter is clearly a finite resource — perhaps the scarcest of the fossil fuels.

Excess nitrogen in the form of nitrates and nitrites is an environmental hazard; nitrates are linked to the occurrence of methemoglobinema (blue baby syndrome), and the U.S. Public Health Service standard for drinking water is a maximum of 10 milligrams of nitrate per liter of water. A conservative figure, thinks Professor Aldrich, and only a few rural water supplies in the midwest and California even approach it.

But nitrate run-off may at some future time provide a limit on agricultural productivity. Though it is still less than one-third of the standard, the nitrate level of the Mississippi River leaving the Corn Belt has doubled since 1956.

Dr. Aldrich is convinced that nitrate run-off into surface and underground waters is in fact proportional to crop production; it cannot be traced simply to excessive fertilizer use. The nitrate content of all midwestern rivers has been rising at about the same rate as total Corn Belt crop production, and Dr. Aldrich predicts "a future confrontation between food goals and nitrate goals."

Technology's Two-Edged Genetic Sword

Germplasm is a more subtle problem.

What crop (only one) now in common use throughout the world originated in North America? A puzzle from Joseph Ewan, Professor of Botany at Tulane University, for the American Association for the Advancement of Science in Boston last winter. Answer: the sunflower. Indeed, only a few food plants introduced into North America before 1650 have retained their importance as sources of food in modern times: corn, peanuts, potatoes, beans, squash, cotton . . .

But today's corn is almost totally different from the Latin American maize given to hungry colonists by friendly Indians before the first Thanksgiving; it is the product of a genetic technology which has substantially altered most of our food plants.

Three results:

— Yields have increased dramatically.

— Most major food plants have lost their independence. Hybrid corn, for example, cannot "grow wild"; it cannot survive or propagate, as could its ancestral maize, without man's intervention. Corn, like many food plants, is a victim of what David J. Rogers of the Taximetrics Laboratory at the University of Colorado calls "retrogressive evolution." Such widespread dependence of food plants on man, Dr. Rogers and three colleagues explained to the A.A.A.S. last winter, simply makes "disasters . . . more likely."

— Farmers are concentrating more than ever before on a few prolific varieties of food plants. Original plant strains — for example, the many Latin American varieties of maize — are neglected, displaced, and imperiled. A paradox, said Garrison Wilkes of the University of Massachusetts: "The product of technology (plants bred for high yield and uniformity) displaces the resource upon which the technology is based (the genetic diversity of locally adapted races)." If all local, primitive plant races are lost to introduced varieties, the last 50 years of plant breeding will turn out to have been like "taking stones from the foundation to repair the roof," Dr. Wilkes told the A.A.A.S. — *J.M.*

Nutrition and the Marketplace

Malnutrition most often arises, not from famine, but from improper diet. And when that is the case, says Cicely Williams, Visiting Professor in Tulane University's Department of Pediatrics, reallocating food for more equal distribution is like "putting a first-aid dressing on a cancer."

"The mental and social contexts of malnutrition must be changed," Dr. Williams told a meeting of the American Association for the Advancement of Science this winter.

An inadvertent contributor to malnutrition has been the "Green Revolution," which Garrison Wilkes, Professor of Biology at the University of Massachusetts, says is substituting easily-grown crops for plants that over the centuries have yielded balanced nutrition. Each world center of carbohydrate production has in the past produced a companion protein: beans, lentils, or chick peas. "But now, native cultivators are dropping those legume crops, even though they account for 25 per cent of direct human protein consumption," Dr. Wilkes points out.

The reason: a shift from subsistence to market agriculture. As market values influence native farmers' choice of crops, carbohydrates become more attractive than proteins, said Dr. Wilkes. Rice, corn, and potatoes require less toil, are cheaper to grow, and, sold by weight, bring higher prices than lighter-weight protein crops.

The market mechanism also pushes the price of protein-rich legumes beyond the reach of the poor, who have greatest need for them.

F. James Levinson, Director of M.I.T.'s International Nutrition Planning Program, criticized the World Food Conference held in Rome last year for implying that "the world food problem is simply a matter of aggregate food availability — that if a country could increase its agricultural production and/or its food imports, all would be well."

Not so, he told another A.A.A.S. forum, noting the absence of a direct relationship between food's abundance and its consumption by the poor. "Given the nature of the income and resource distribution in these countries and the development patterns being pursued, the poor — perhaps 30 or 40 per cent of these populations — benefit relatively little" from increases in food production, Dr. Levinson argues. They simply don't have the purchasing power to buy what's available on the market.

Nutrition programs must address more effectively the social conditions that can cause malnutrition, Dr. Levinson said. In addition to agricultural improvement, he advocates government investment that creates employment among the poor and generates income, much of which is spent on food. In the short run, production may not be able to keep pace with this increased demand; prices will rise unless more food is made available. And here, Dr. Levinson differs with Dr. Williams, advising wealthier nations to expand rather than reduce their food aid programs. He believes that under such conditions, food aid can permit governments to pursue the employment-oriented, participatory patterns of development which the U.S. and other industrialized nations should encourage. — *D.McG.*

City Food Factories

City gardens are farms of limitations, nurtured with a minimum of sun, soil, and space. Ideal for urban farming is a new method based on experimental horticulture in Europe at the turn of the century. According to John C. Jeavons of Ecology Action of the Midpeninsula in California, the biodynamic/French intensive method uses a fraction of the nitrogen, fertilizer, water, and energy consumed by standard techniques, per pound of food produced. A brief how-to of the method:

Loosen the soil, retaining stratification, to a depth of 24 inches. This enables plant roots to penetrate easily, allowing a steady stream of nutriments to flow into stems and leaves. Moisture is retained, weeding simplified, erosion minimized. Don't plant rows of troughs; instead, plant across the bed (all seeds equidistant) to create a canopy of leaves in the mature plants. This provides a "mini-climate" under the leaves which retains moisture, protects valuable microbiotic soil life, and retards weed growth. Place compatible plants near one another: green beans and strawberries, for instance, thrive when grown side by side.

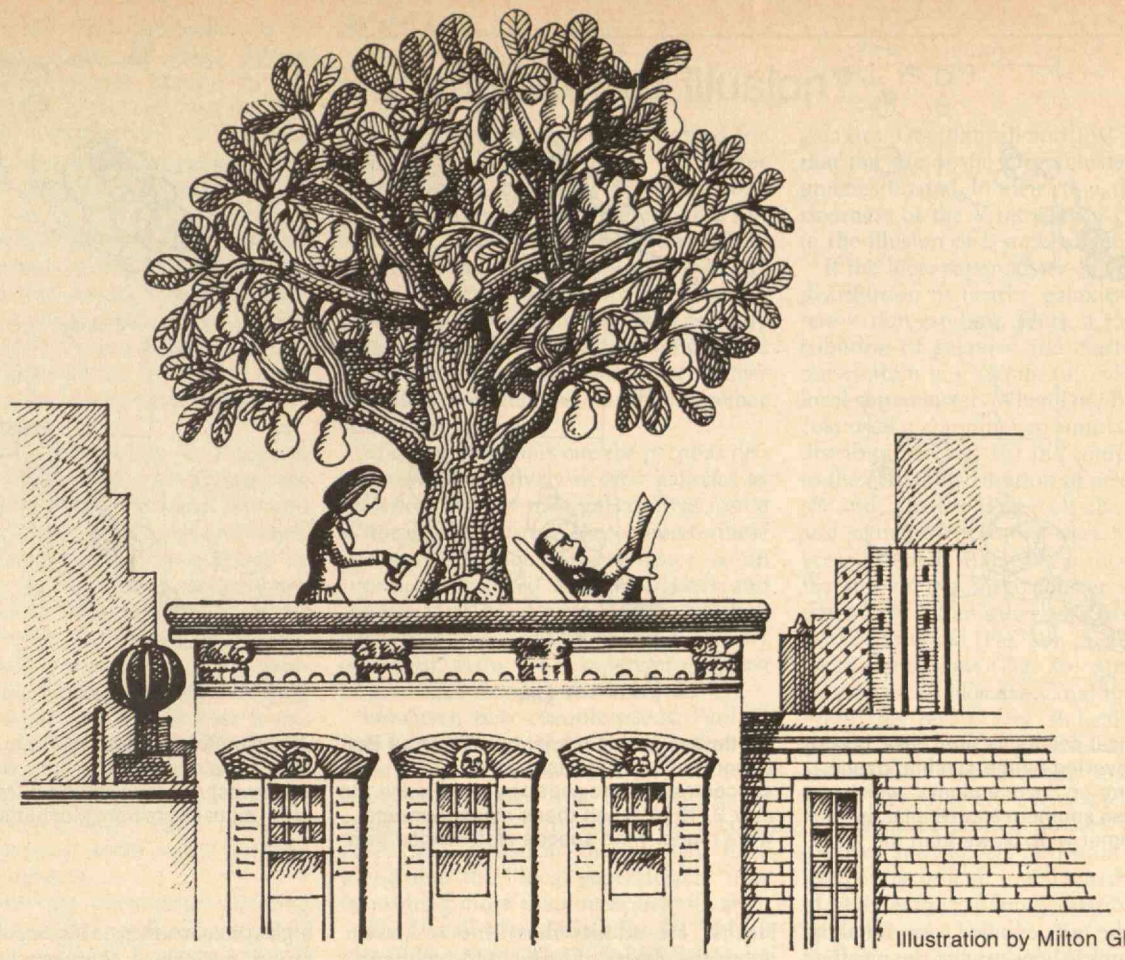


Illustration by Milton Glaser

Garbage, vegetation, and manure, when properly composted, can maintain maximum plant health at minimum expense. To integrate kitchen waste into food production, store it with grass and leaves in small bins covered with sawdust, says Helga Olkowski, Research Associate at the University of California at Berkeley. If the bin is sealed, kept at 160 degrees for several days, and turned every two or three days, you will have a complete growing medium in three weeks. It can be used directly and is extremely light — perfect for pots on the roof. And the hot compost will kill weeds, destroy plant pathogens, and eliminate flies by killing their larvae.

Chemical pesticides pose tremendous safety problems in urban areas: they fall indiscriminately on lawns, tricycles, and pets. They are fat-soluble and biomagnify. And they can even be counter-productive: many potential pests are controlled by other insects — until pesticide use ruins the balance of natural enemies. In every population of insects, some are resistant to pesticides. These remain to build a more resistant population. The more a chemical is used, the more pronounced this selection becomes. Now, in some areas, insects are resistant to all known pesticides, says Dr. Olkowski.

Only three per cent of the U.S. population cultivates food. It's as if a small number of people were charged with breathing for the rest of us, says Carter Schelling, also of Ecology Action. The ideal approach to agriculture, he feels, is a close daily bond between each person and his food — the home production of basic needs.

Ecology Action speculates (on the basis of four years of quantitative agriculture) that individual homeowners could grow complete, balanced diets for themselves on as little as 1,250 square feet per person (a small fraction of the normal U.S. per capita requirements for a similar diet) while expending only 15 minutes per person per day in labor. They estimate, too, that a backyard gardener in a six-month growing season could produce a year's supply (325 pounds) of vegetables and soft fruits like melons or strawberries on 160 square feet or less. Thus food worth $120 could be grown in about ten minutes a day. — *M.L.*

ENVIRONMENT

Indoor Air: A Roomful of Blues

Air quality usually refers to pollution levels out of doors from industrial combustion, automobile exhausts, and nuclear reactors. But at least 75 per cent of most people's lives is spent indoors, and the quality of indoor air is a perversely neglected question.

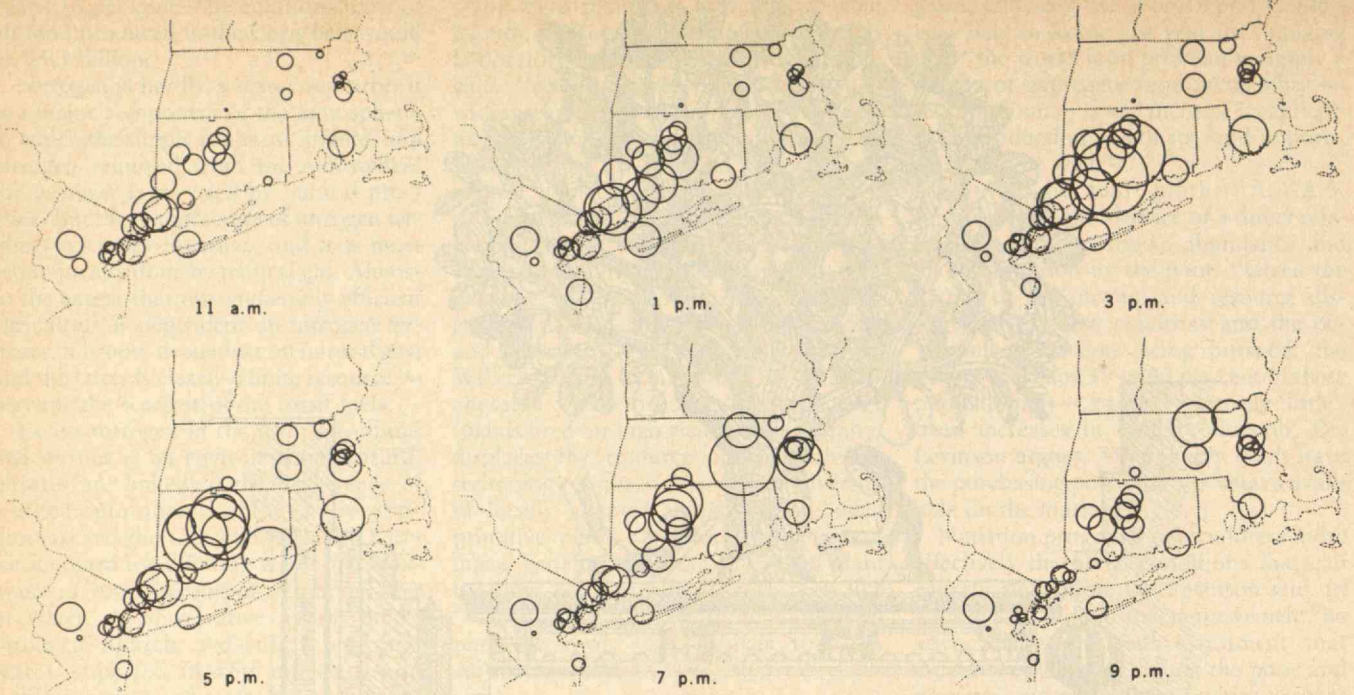
The same pollutants which compromise outdoor air quality are found indoors, says John E. Yocum of the Research Corporation of New England: carbon monoxide is in essentially the same concentrations as outdoors (unless there is an inside source, such as an improperly vented heater), sulfur dioxide appears in lower concentrations (SO_2 reacts with other materials in the presence of moisture, and indoor environments usually are more humid than outdoor ones), and floating between are particulates (those indoors are likely to be smaller than those outdoors, and to contain more lead). There are also kitchen-generated aerosols about which little is known.

If smokers are present, there is superimposed on this pattern of indoor air pollution a burden of particulate matter almost without parallel in outdoor situations.

The Smoker as Filter

Cigarette smoke is "a vastly complex material," says Dr. Morton Corn, Assistant Secretary of Labor who heads the Department's Occupational Health Section; its chemicals are suspended as particles averaging only 0.15 microns in size. All such particles are respirable; indeed, they are small enough to penetrate to the farthest recesses of the lung.

There are about 1,000 million such particles in a cubic centimeter of cigarette smoke as a smoker inhales it. Only 30 per



Photochemical pollutants from New York City are converted by the sun into ozone, and they form an "ozone plume" which moves across southern New England when the hot summer wind blows from the southwest. In this presentation by four Bell Laboratories scientists, ozone concentrations are coded by circle sizes. On July 2, 1974, when these measurements were made, wind speeds aloft ranged from 40 kilometers an hour at 7 a.m. to 36 kilometers an hour at 7 p.m., from the southwest — representing a transit time of six to eight hours from Manhattan to Boston.

cent of these are exhaled. An inhaling smoker retains 70 per cent of the particulates he breathes: if nothing else, he is at least a good filter for the non-smokers exposed to his habit.

They need it. Smoking is clearly a significant source of air pollution for non-smokers. Before he took his present job in Washington, Dr. Corn (he is on leave from the School of Public Health at the University of Pittsburgh) made some tests: in a typical home (450 cubic meters), the particulates from the smoke of two cigarettes an hour will accumulate to exceed the Environmental Protection Agency's maximum permissible level.

Smokers at an Early Age

Children, especially, are susceptible to indoor air pollutants. They breathe more air per unit of body weight than adults, and — even ignoring the extra dust which they stir up in play on the floor — the air they breathe at floor level is dirtier than the air at adults' level. Two examples from recent research: the concentration of lead particles at 1.5 meters is twice that at 20 meters, and the concentration of ozone is four times greater at one than at two meters.

All this has made Dorothy Noyes Kane of Walden University, Connecticut, a "card-carrying maverick," convinced that "child care people should have greater concern for the effects of dirty air on children's physical and mental health." She has an ally in Dr. Benjamin G. Ferris, Jr., of the Harvard School of Public Health. He admits that little is known about the effects of household pollutants, but he told the American Association for the Advancement of Science in Boston last winter (where all these remarks about indoor air quality were made) that he observes, in general, "an increased level of respiratory symptoms in children whose parents smoke." — *J.M.*

Mapping New York's Ozone Plume

The "smoky southwester' " that brings hot, humid weather to New England — and makes Maine "down east" from Boston — draws a straight line from Manhattan across Connecticut to Massachusetts. Along that expressway come New York's photochemical pollutants, converted en route by the sun to levels of ozone in Connecticut and Massachusetts far in excess of the federal standard of 0.08 parts per million (hourly average).

Correlations of air quality data with National Weather Service wind records have convinced four scientists at Bell Telephone Laboratories — W. S. Cleveland, B. Kleiner, J. E. McRae, and J. L. Warner — that "primary emissions in the New York City metropolitan area have a substantial effect on ozone concentrations at downwind areas of Connecticut and Massachusetts." The prime target is the Greenwich-Stamford area of Connecticut, but Fitchburg and Fall River, Mass., show high concentrations, too, according to the report in *Science (January 16, pp. 179-181).*

On some occasions, an air quality monitor in Chester, New Jersey, southwest of Manhattan, recorded ozone levels above the federal standard in air moving toward Manhattan from the southwest; on those days, New York was simply making a bad situation worse for the rest of the northeast. — *J.M.*

ENERGY

Surprise at the Top of the Fusion Ladder

Alcator, M.I.T.'s Tokamak fusion machine, achieved the best containment of high-temperature plasmas yet achieved by any fusion device last November. The plasma density-confinement time product was raised to 10,000 billion (10^{13}) seconds per cubic centimeter, five times better than any other fusion device.

But now the researchers are puzzled. Their machine, operating at the outer limits of fusion physics, has produced plasmas with properties quite at odds with simple theory, and seemingly at odds with common sense.

The M.I.T. machine, like other Tokamak-type devices, features a doughnut-shaped chamber designed to surround and confine hot plasmas in powerful magnetic fields. This "endless loop"

geometry has proved a powerful way to hold plasmas. Like all other fusion machines in existence, Alcator is not meant to finally attain the "breakeven" point — the temperatures, density and confinement time at which plasma particles will fuse and yield more energy than is injected into them. Its purpose is only to push the physical limits as high as possible, to learn how plasmas behave at high temperatures and strong magnetic fields. The latest Alcator confinement results were achieved at about a tenth of the 100 million °K. required for fusion and were but a tenth of the density-time product required for fusion.

Alcator is different from its Tokamak cousins principally in that its magnets are sprayed continuously with liquid nitrogen during experiments; the low temperatures reduce the resistance in the magnets to one-seventh that at room temperature thereby allowing more electricity to be pumped through them and far higher magnetic fields to be attained. The new results were obtained with a magnetic field of 75 kiloGauss, and the machine is expected to be able to reach 100 kiloGauss. The Alcator machine is also known for its excellent vacuum system which has allowed an exceptionally "clean" plasma, free from impurities which might spoil the plasma containment.

Now comes the peculiarity: diddling around at these high containment regions, the Alcator researchers discovered that if they increased the density of plasma at a given magnetic field, the plasma confinement time would get better. Theory holds (logically?) that the more plasma particles pumped into a magnetic bottle, the less time they would be confined. This is because particles move across the magnetic field by colliding with each other: the higher the density the higher the collision rate, and therefore the faster loss of particles. So, the physicists are puzzling over their graphs: the theoretical graph of containment time versus density slashes downward from upper left to lower right (higher density, lower time); their Alcator graph scoots up at right angles to this, from lower left to upper right (higher density, higher time). So far, the curves have remained at odds with one another at all of the high magnetic field strengths the experimenters have tried.

And there is another puzzle: when the Alcator line rises to meet the theory line — that is, as the experimenters stuff more and more particles into their magnetic bottle — things get better and better, until the theoretical line is bumped up against, and then the plasma falls apart, no longer contained by the magnetic fields.

The physicists joke that at this fleeting crossroads of theory and reality, the theory holds beautifully. But then they go back to their blackboards, puzzled. — *D.M.*

ASTROPHYSICS

Supercluster or Illusion?

Astronomers have for years searched for patterns in the distribution of matter within the universe. Our sun is but one star in a galactic swarm of a hundred billion stars. At least ten billion other galaxies are found throughout the universe. Many of these galaxies are bunched together — sometimes in clusters of as many as tens of thousands of galaxies. But is the universe ordered on even larger scales? Are clusters of galaxies bunched together into superclusters?

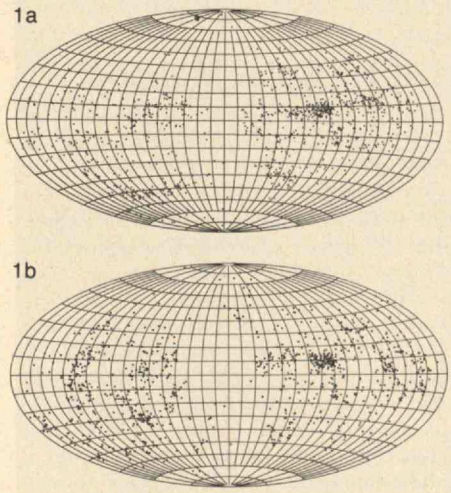
Many astronomers cite the peculiar distribution of relatively nearby galaxies as evidence that our own galaxy lives inside a "local supercluster." According to these scientists, the local supercluster is an enormous flattened disk of galaxies and clusters of galaxies, a few hundred million light years across. If they are right, then by induction, many other superclusters must be sprinkled through the universe.

However, two astrophysicists, Paul C. Joss of M.I.T., and John N. Bahcall of the Institute for Advanced Study at Princeton, have re-examined the distribution of nearby galaxies. With the aid of a computer and statistical theory they have found that the "local supercluster" may be nothing more than an optical illusion.

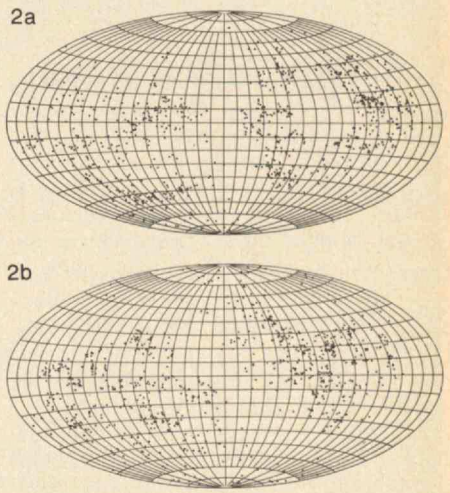
The local supercluster under debate looks like a dense band of nearby galaxies and clusters of galaxies (Fig. 1a). The band runs through the Virgo cluster, a major cluster containing thousands of galaxies. Drs. Bahcall and Joss speculated that the size of the Virgo cluster has been underestimated. In their view, the size and closeness of the Virgo cluster contributes to the illusion of a supergalactic band.

If the local supercluster exists, then the distribution of nearby galaxies and clusters is non-random. Thus, a random distribution of galaxies and clusters should not contain any significant evidence of a local supercluster. When Drs. Bahcall and Joss used a computer to simulate random distributions (Fig. 1b) and compared them to the actual distribution of nearby galaxies and clusters (Fig. 1a), the simulated and actual distributions were found to be very different. But, when they assumed the size of the Virgo cluster was a few times larger than other astronomers have usually assumed (Fig. 2a), then their computer simulations (Fig. 2b) turned out to be very much like the actual distribution. From this result, Drs. Bahcall and Joss suspect that nearby galaxies and clusters are randomly distributed, and that no "local supercluster" exists after all.

Because of limited powers to observe galaxies and clusters in distant regions of space, it is difficult to tell whether clusters of galaxies are randomly distributed in the universe as a whole. But the interim findings are still consequential. If there is indeed no local supercluster, then the nearby galaxies should have relatively little gravitational influence upon one



Top: A map of the observed positions of nearby bright galaxies in the sky (from a catalog compiled by H. Shapley and A. Ames). Each dot represents a galaxy. The Virgo cluster appears as a large clump of galaxies in the center right. The so-called "local supercluster" is the denser band of galaxies that runs roughly horizontally across the center of the map. *Bottom:* A map of a computer-simulated random distribution of nearby galaxies and clusters. There is relatively little evidence for a local supercluster band.



Top: A map of nearby bright galaxies, excluding all galaxies within 25° of the center of the Virgo cluster. *Bottom:* A map of a computer-simulated random distribution of nearby galaxies and clusters, again with the Virgo cluster excluded. Both maps now show equally little evidence for a local supercluster band. On the basis of such computer-simulated maps, Drs. Bahcall and Joss concluded that the "local supercluster" may be nothing more than an optical illusion due largely to the distorting effects of the nearby Virgo cluster.

another. Thus astronomers will find it easier to interpret observations of the expansion of the universe and the motion of our own galaxy through the universe. — *Melissa Weiksnar*

TELEPHONE CENTENNIAL

The Transparent Telephone

With today's venomous debates over nuclear power plants, automobile pollution, and pesticides, it is hard to believe that there is a machine in our midst so benign that we have not bothered to study its significance — the telephone.

And so mild bewilderment was the strongest emotion exhibited by conferees at a recent symposium on the social impact of the telephone. The symposium marked the 100th anniversary of the telephone's invention — March 10 — which the sponsors, AT&T and M.I.T., celebrated with a relaxed look at Alexander Bell's brainchild.

It was not difficult for the symposium participants to ferret out the reasons for the telephone's obscurity in the annals of social science:

"One almost never hears of a serious accident or fatality caused by the telephone," said M.I.T. Professor Ithiel de Sola Pool. "Furthermore, people choose how they use the phone; it is not outside their control the way one-way media or traffic are . . . It is a facilitator, allowing people to do more easily whatever it is that they decide to do."

Professor Pool contrasted the telephone with such inventions as railroads, which "decide" where factories are to be located, and disrupt communities with noise and smoke. Another invention just as ubiquitous as the telephone — television — offers us almost no control over what is beamed into our houses.

Perhaps the telephone is the most "transparent" invention around. It is instantly useful and requires no training. And it transports the most natural, information-rich part of our personality — our voice — immediately and over vast distances.

For these reasons, the telephone will be a natural tool to aid developing countries, where literacy is low and verbal communication dominates, said Colin Cherry, Imperial College, London.

We are so naturally dependent on the telephone that when it fails, we become almost desperate, agreed the conferees. One participant cited interviews with New Yorkers deprived of telephone service by a fire last year. The urbanites felt a nagging sense of insecurity without the instant access to help afforded by the phone.

As writer Martin Mayer pointed out, "One of the standard terrifying incidents relied upon by authors of television [thrillers] is the sight of the knife cutting the telephone line."

Mr. Mayer was one of many at the conference who was "astonished that so little work has been done by sociologists (or indeed anyone else) to investigate what the telephone has meant, and means, to daily life in this country." To correct that omission, the participants made a concerted effort to figure out the telephone; their conclusions were double-edged.

For example, on the one hand, the telephone allowed factory to be separated from office, encouraging urban sprawl, but it also made the skyscraper possible because it allowed such free communications in the dense structures.

It provided the indispensable network of communications that allowed complex cities to function and be livable, but it also enlivened country life.

"The telephone has helped make the city bigger, better, more efficient, more exciting," said Jean Gottman of the University of Ontario. "It alleviates loneliness, it helps arrange encounters. It saves its users time, trips, and frustration. . . . The major urban message the telephone carries is still the same as the first call of Bell to Watson: 'I want to see you.' "

The telephone makes suburban and rural life safer and saner, said Professor Gottman, by providing the instant communication that links isolated families to the outside world.

Professor Pool continued the two-way slice: "The telephone has helped police catch criminals, but it has also helped criminals evade police. On the one hand its ringing invades our privacy; on the other, in the telephone era it is no longer acceptable to drop in on people without warning them by phone in advance.

"The telephone, in short, has expanded human freedom. What can be harder than defining the consequences of freedom?" — *D.M.*

A Neutron Star Weighs In at 1.7 Solar Masses

Less than a month after it was launched last spring, the x-ray observatory in SAS-3 (*see left*) chanced to record a flare of x-rays from Vela X-1, one of eight known "binary x-ray systems" — which means that each contains a normal star and a compact, heavy one orbiting closely about each other.

Professor Saul A. Rappaport, who was monitoring data from M.I.T.'s x-ray observatory, asked N.A.S.A. to point the satellite at Vela X-1 for a longer look. The x-ray source was then discovered to be pulsing, the intensity of its x-ray emission varying over a 283-second period.

If, as most scientists assume, the pulsing is caused by a "hot" spot on the star, the pulse period is a measure of the time it takes the star to rotate. Making that assumption, Professor Rappaport and his associates at M.I.T. made Doppler shift measurements to learn the speed and path of the star. From these, in turn, could be inferred the gravitational attraction between the normal star and its heavy partner, and this led to a mathematical relation between the two masses.

The result: the compact, collapsed star in Vela X-1 is only ten miles in diameter but 1.7 times as heavy as the sun. Its partner is about 20 times as massive as the sun and about 30 times larger in diameter. Vela X-1 thus is shown to consist of this giant blue star and a tiny neutron star; the calculation represents the first time that a neutron star has been "weighed" and a significant confirmation of the theory of binary x-ray systems.

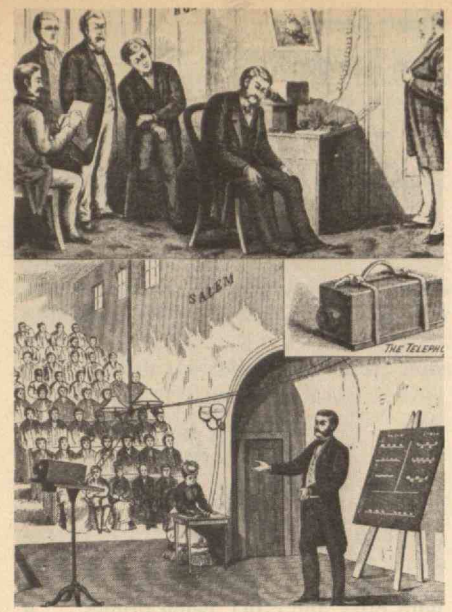
A pea-sized chunk of the neutron star in Vela X-1, a collapsed star remnant whose atoms are crushed together to incredible density, would weigh 1×10^9 tons. — *J.M.*

The Computer at Puberty

The computer already seems to be everywhere, doing everything, but according to a group of prominent computer scientists, the industry has only just begun an explosive growth. Over the next two decades it will enter home, business and factory as never before.

This was the principal conclusion of preliminary reports on an extensive study of "The Future Impact of Computers" being performed by computer and social scientists at IBM, Stanford, M.I.T., Harvard, Yale, Princeton, and other prominent institutions.

The study, coordinated by Michael L. Dertouzos, Director of M.I.T.'s Laboratory for Computer Science, and Joel Moses, Associate Director, is sponsored by AT&T, IBM, the Office of Naval Research, and M.I.T. To be completed in 1977, it consists of an integrated series of carefully thought-out and hashed-over papers on key topics in the computer field. The participants in the study, key people in their fields, occupy excellent vantage points to ponder the computer's future, said Professor Dertouzos. But, perhaps



Professor A. Graham Bell demonstrated his amazing invention the telephone before an awed audience in 1877, by communicating between the lecture hall and his office 15 miles away. (Woodcut from *Scientific American*, March, 1877, courtesy AT&T)

just as important, their influence could make their predictions self-fulfilling prophecies.

At the symposium marking the 100th anniversary of the telephone, many of the participants in the study gathered to offer a fascinating glimpse into a future stuffed with computers.

The hardware of the computer should be about the least restraining influence on the computer's future, according to scientist-entrepreneur Robert N. Noyce, Chairman of Intel Corp. His analysis shows that the size of computer components could be reduced a hundred to a thousand times, from even the tiny circuits of today, before they begin bumping "down" against the fundamental thermal noise limits on size. And technological advance has allowed the complexity of integrated circuits to double every year since 1960, he pointed out, a trend that should continue, allowing ever lower costs for ever more powerful computers. The future almost certainly holds reductions in size and cost, and increases in complexity as remarkable as those that brought pocket calculators from the engineer's workbench to citizen's pockets.

The Computer at Home

The key to these technical advances is continuing profitability, said Dr. Noyce. His company is a leader in the high-technology semiconductor industry. For the computer to remain a profitable product, said Dr. Noyce, it must become a mass-market item. And according to Professor Moses, the computer will mount a massive invasion of the home over the next two decades.

The first wave, said Professor Moses, will consist of computers which perform tasks not requiring connection to a communication network — such networks will probably bring up the rear in computer developments.

Professor Moses foresees computer games and other recreations, "smart" household appliances, home education programs, and efficient household heating and cooling control as the first uses for home computers. Indeed, many such products have already appeared in the marketplace: computer-controlled machines now being marketed include microwave ovens, television sets, automobiles, and, of course, the popular electronic games, which can be played through one's TV.

Eventually, however, computer communications networks for the home will evolve, and subscribers will have enormous volumes of information at their fingertips — via home computer consoles that will cost about as much as today's color TV sets. Computerized encyclopedias, electronic mail, and enormous electronic "newspapers" which would allow the reader to delve into whatever subject at whatever depth he wished. Also possible would be a new form of electronic "junk" mail — when a subscriber wished to buy something, he could use his computer to summon all the current advertising for the product, and comparison shop from his easy chair. This divorce of news from advertising could also affect the content of news, noted Professor Moses. No longer would a reporter on auto safety worry about irate car dealers cancelling ads, should he criticize their product.

There will also be other changes in the kinds of information we receive, with the advent of the "information utility," according to John McCarthy of Stanford. Computerized publishing would increase competition, because the expensive printing process would be eliminated. As soon as a manuscript was ready, it could be instantaneously available. The nature of public controversy in the computer age would also change, said Dr. McCarthy. When one candidate attacked another over the computer news network of the future, the average citizen could immediately dial up the opposing statements. Thus, public stands would be much more carefully considered before being made public. Also, government information would be truly public for the first time. Instead of being stored away in dusty archives, available only to those with the wherewithal to dig it out, the data would be instantly available on the average person's home console.

Giving Computers the Business

Although business and industry are already heavy users of computer power, they will become even more so in the future, according to the study participants. One major trend will be toward the "paperless office," said Victor A. Vyssotsky of Bell Telephone Laboratories. Records and communications will be stored and transmitted by computers rather than as pieces of paper. However, said Dr. Vyssotsky, the clerical worker will by no means be out of a job; rather the nature of his job will change drastically, from paper shuffler to electron pusher. Computer methods for assisting managers would also make gradual progress as business tools.

"Overall, I anticipate a modest steady improvement as a result of further computerization of business functions," said Dr. Vyssotsky. "At a very rough guess, this improvement, over the next twenty years, may be something like two per cent per year for a force which may run somewhere around forty per cent of the U.S. work force."

Manufacturing will also see much greater use of computers than even today, according to Professor Dertouzos, who wrote the portion of the study on that subject. The key technical developments in this area will be programmable robots with senses of touch and sight; microcomputer-operated control systems integrated into aircraft, autos, home and factories; and networks of robots or control systems capable of working together.

Out of these technologies, Professor Dertouzos sees emerging automated factories that could produce products tailored specifically to each customer. For instance, a customer might order shoes fitted to his foot measurements, and the shoes would be manufactured on the spot. Such automation would revive U.S. industries currently being strangled by cheap foreign labor. Also, said Dr. Dertouzos, robots would continue to take over dangerous jobs, preserving human life; and they would relieve humans of mindless tasks, enabling them to do truly humane tasks.

"While the popular view of an automated future involves a heartless and mechanistic society geared to productivity and efficiency, I advocate the opposite view that computers will improve and humanize our way of life," he said.

The major plea throughout all the scientists' discourse was — as Terry Winograd of Stanford University put it — that computers be "peoplized." The computer must be taught to adopt the style of communication natural to people, and not the foreign language it is now allowed to use. Computers that understand human dialogue, that can take human speech as an input, and that can explain their actions and reasoning to humans will represent major steps in this direction.

Perhaps then the computer will become as benign and helpful an invention as is the telephone, whose 100th anniversary the conferees were observing. — *D.M.*

Philately, Cryptarithmetic, and a Three-Legged Stool

Puzzle Corner
by
Allan J. Gottlieb

When we read the January issue, R. Robinson Rowe and I were surprised to find no speed problems. I referred to my original manuscript, and — sure enough — just plain forgot them. Sorry.

York College now has its own zip code, and I have a new position as you may have noted in the March/April issue. My job is now Coordinator of Computer Activity, and the zip is 11451; the complete address appears, as usual, at the end of the column. I guess I have to admit that, with the New York City budget crisis, my address might change again soon?

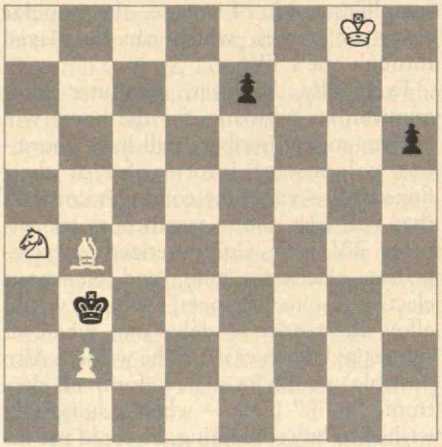
John Melchiori, a colleague of mine at York College, and I are writing a computer program to play chess, hoping to enter it in the North American championships in October. The program is named ALMA after our wives, *Al*ice and *Ma*ria, who are sacrificing Saturdays for the cause. Perhaps, soon it will be able to solve "Puzzle Corner" chess problems; currently ALMA finds any mate in one. Any advice would be welcome.

Problems

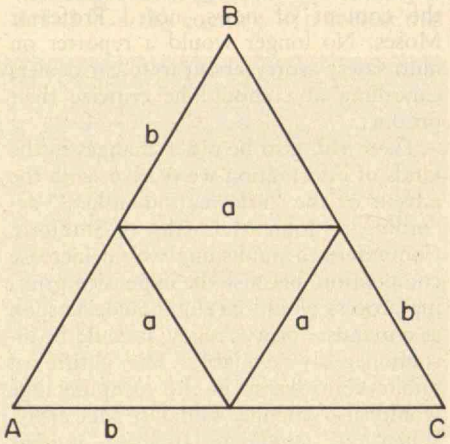
As you may recall, in December we began a policy of presenting old problems which were never completely solved. The following "stamp problem" appeared the month of my M.I.T. graduation, June, 1967. It doesn't seem that bad.

NS3 Suppose the government wants to revise its philatelic system and create only seven denominations of stamps. To aid in automatic processing, a maximum of only three stamps is to be permitted on an envelope (two or one are also permitted). Up to what value of postage will this cover without a break? What are the denominations of the stamps required to achieve this? When the problem first appeared, Richard L. Heimer solved it using a "brute force technique" on a digital computer; his answer: 70 cents using stamps of 1¢, 4¢, 5¢, 15¢, 18¢, 27¢, and 34¢. But he was troubled because he could not solve problems of this general class without resorting to the "brute force" method, and we still wait for such a solution.

MAY 1 We begin with an endgame problem from Harry Nelson. Given the following, White is to play and win.



MAY 2 Robert Kimble, Jr., wants you to show that, given the equalities shown in the diagram, triangle ABC is equilateral.



MAY 3 Avi Ornstein says the following is a cryptarithmetic problem, a kind he's not previously seen in "Puzzle Corner" in three years of reading. For those who are not introduced, a cryptarithmetic problem has letters in place of digits. The problem is resolving which digit each letter represents:

A BOY asked a GIRL to become his wife
When each one was in the prime of their life.
If they simply add LOVE, there is but one hope . . .
The result of it all is that they ELOPE.

The poem represents the mathematics problem:

```
  BOY
 GIRL
+LOVE
-----
ELOPE
```

with BOY and GIRL being primes.

Mr. Ornstein notes that he originally concocted this problem in high school, but it had many solutions. By requiring that BOY and GIRL be primes, the problem is limited to one solution. (Cryptarithmetic problems have appeared in the past, but rather infrequently. — Ed.)

MAY 4 Dan Fingerman attributes the following problem to George Pillai: A four-legged stool stands on an uneven floor. There are no sudden steps, but the floor is wavy, with bumps and hollows. The stool will stand, of course, with three legs touching the floor. Is it always possible to turn and/or move the stool so that it stands firmly with *all four* legs touching the floor?

MAY 5 Our final regular problem is a fifth-grade homework problem which Kier Finlayson modified for *Technology Review*: A square number is one which can be represented by an array of points in the form of a square. Similarly, a triangular number is one which can be represented by an array of points in the form of an equilateral triangle. The square numbers are 1, 4, 9, 16, 25, 36, . . . The triangular numbers are 1, 3, 6, 10, 15, 21, 28, 36, . . . The first number after 1 which is both a square and a triangular number is 36; what is the next number which is both square and triangular?

Speed Department

MAY SD 1 We begin with a selection from John Rule: A three-volume set of books, each book 100 pages long, is placed on a bookshelf in the usual order, from left to right: volume 1, volume 2, and volume 3. The covers are all ⅛ inch thick; 100 pages are 1 inch thick. A worm starts between the front cover and page 1 of volume 1 and eats perpendicularly into the books until he is between page 300 and the back cover of volume 3. How far does he eat?

MAY SD 2 A nautical quicky from Emmet J. Duffy: A vessel is anchored

three miles offshore, and opposite a point five miles farther along the shore another vessel is anchored nine miles from the shore. A boat from the first vessel is to land a passenger on the shore and then proceed to the other vessel. What is the shortest course for the boat? (No calculus, please.)

Solutions

The following are solutions to problems published in *Technology Review* for January.

JAN 1 With the following hands, clubs are trump and North is to lead.

	♠ A 2 ♥ A 2 ♦ A 4 3 2 ♣ —	
♠ K Q ♥ K Q ♦ K Q J 10 ♣ —		♠ J 10 9 ♥ J 10 9 ♦ 9 8 ♣ —
	♠ 4 3 ♥ 4 3 ♦ — ♣ 5 4 3 2	

The problem: North and South to take all eight tricks against any defense.

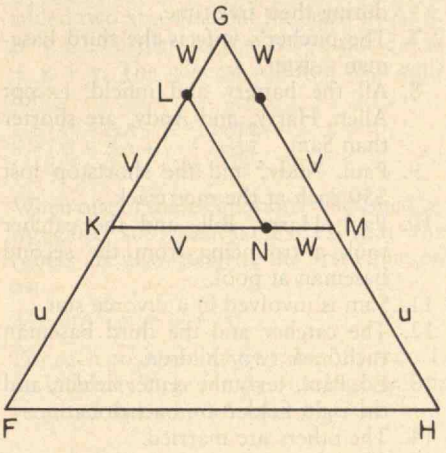
J. C. Kingery writes that he enjoys "Puzzle Corner" but is "rarely able to find a solution." But he was able to untangle this one: 1. North leads a low diamond, South ruffs. 2. South leads trump; West must hold diamonds to avoid establishing North's fourth diamond; if he discards a heart, North discards a low heart; East will discard a diamond. 3. South leads a heart, North takes the trick with ♥ A. 4. North leads ♦ A, South discards a low spade. 5. North leads a low diamond and South ruffs. The distribution is now as follows:

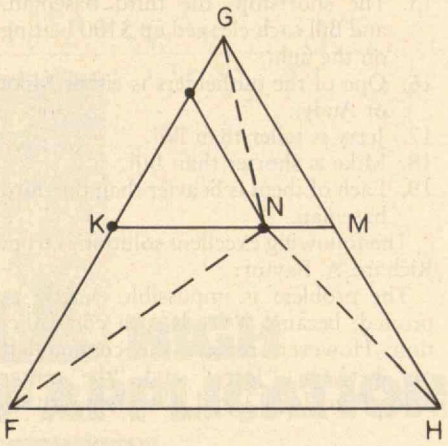
	♠ A 2 ♥ — ♦ 2 ♣ —	
♠ K Q ♥ — ♦ K ♣ —		♠ J 10 ♥ J ♦ — ♣ —
	♠ 3 ♥ 3 ♦ — ♣ 3	

If East is holding any other combination, spades or hearts will already be set up. 6. South leads the final club; if West discards the diamond, North discards a spade and the board is good; if West discards a spade, North discards the diamond. 7. East is now squeezed; if he discards the heart, South's heart is established and the ♠ A is the eighth trick. If East discards a spade, South will lead a low spade to North's ♠ A, establishing the final spade. 8. If, on the second trick, West discards a spade, North discards a low spade. The procedure is the same with the play of hearts and spades reversed. East plays a passive role in the hand — i.e., his best defense will not affect North/South play of the hand until the final squeeze.

Also solved by Rex Ingraham, Noland Poffenberger, Winslow H. Hartford, Michael A. Kay, William J. Butler, Jr., Paul W. Abrahams, Peter Wityk, Charles Polay, and the proposer, Emmet J. Duffy.

JAN 2 Consider two triangles ABC and PQR. Angle ABD = angle BDC = angle CDA = 120°. Prove that X = u + v + w. (The problem was published with X = u − v − w; since everyone who noticed that the problem was obviously false as printed also was able to deduce the correction, I will present the solution this month.) The following is from John F. Chandler:





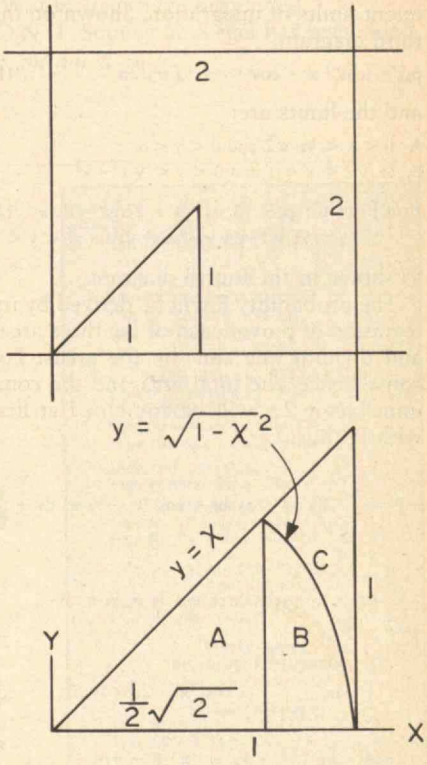
Construct an equilateral triangle FGH with side u + v + w. Without loss of generality, we may assume u ≥ v ≥ w, as shown, and mark segments FG and GH with distances u, v, and w to locate points K, L, and M. Angle KGM is 60°, and KG = GM, so triangle KGM is also equilateral and KM = KG = v + w. Locate point N on KM and note that triangle KLN is also equilateral. Thus angle FKN = angle HMN = angle GLN = 120°. Now draw in segments GN, FN, and HN and observe that triangle FKN is congruent to triangle ABD, triangle HMN is congruent to triangle ADC, and triangle GLN is congruent to triangle DCB. Thus FN = c, HN = b, and GN = a. Note that the construction is unique in that the law of cosines provides unique solutions for angle FNG, angle FNH, and angle GNH in terms of a, b, and c. Thus triangle FGH is congruent to triangle PQR and x = u + v + w.

Also solved by R. Robinson Rowe, Harry Zaremba, William J. Butler, Jr., and the proposer, Mary Lindenberg.

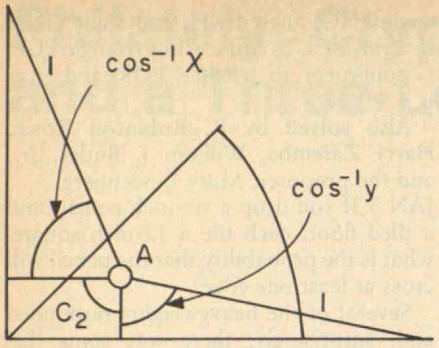
JAN 3 If you drop a six-inch pencil onto a tiled floor, each tile a 12-inch square, what is the probability that the pencil will cross at least one edge?

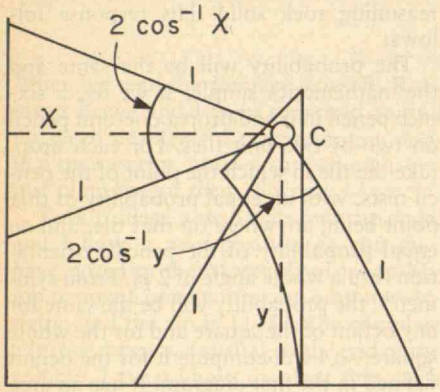
Several of the heavyweights responded and, surprisingly, there was some disagreement among their answers. Not surprisingly, I found R. Robinson Rowe's reasoning rock solid. His response follows:

The probability will be the same and the mathematics simpler if we use a six-inch pencil unit and drop a one-unit pencil on two-by-two-unit tiles. For each drop, take the tile in which the point of the pencil rests, with an equal probability of that point being anywhere on that tile, and an equal probability of the pencil's orientation thru a whole angle of 2 pi. From symmetry, the probability will be the same for any octant of the square and for the whole square, so I will compute it for the octant defined in the first diagram. It has an area of A = ½.



The second diagram shows this octant divided into three parts labeled A, B and C, with limits defined. Any random point will be defined as (x, y) from the axes shown. Let P be the probability for the tile and any octant. Let p be the probability for any point — varying from 0.75 at the origin to 0.0 at the center of the tile and 0.50 along the circular arc. For any point, p will be the ratio of the angle between intercepts on tile edges and the whole angle 2 pi.





Parts A and B have the same p but different limits of integration. Shown on the third diagram,

$$p_{ab} = (\cos^{-1} x + \cos^{-1} y + \tfrac{1}{2}\pi)/2\pi \qquad (1)$$

and the limits are:

A $0 < x < \frac{1}{2}\sqrt{2}$ and $0 < y < x$

B $\frac{1}{2}\sqrt{2} < x < 1$ and $0 < y < \sqrt{1 - x^2}$

For Part C: $p_c = (2\cos^{-1} x + 2\cos^{-1} y)/2\pi \qquad (2)$

$\frac{1}{2}\sqrt{2} < x < 1$ and $\sqrt{1 - x^2} < y < x$

as shown in the fourth diagram.

The probability P will be derived by integration of p over each of the three areas and dividing the sum by the areas. For convenience, the total area and the common factor 2π will be combined at first with P, thus:

$$\pi P = \int_0^{1/4\sqrt{2}} dx \int_0^{x} (\cos^{-1}x + \cos^{-1}y + \tfrac{1}{2}\pi)\, dy +$$

$$\int_{1/2\sqrt{2}}^{1} dx \int_0^{\sqrt{1-x^2}} (\cos^{-1}x + \cos^{-1}y + \tfrac{1}{2}\pi)\, dy$$

$$+ \int_{1/2\sqrt{2}}^{1} dx \int_{\sqrt{1-x^2}}^{x} (2\cos^{-1}x + 2\cos^{-1}y)\, dy \qquad (3)$$

$$= (\pi/4 + \tfrac{1}{2}\sqrt{2} - \tfrac{1}{2}) + (\pi^2/8 - \pi/4 - \tfrac{1}{2}\sqrt{2} + \tfrac{3}{4}) + (1\tfrac{1}{2} - \pi^2/8) = 7/4 \qquad (4)$$

Whence finally,

$$P = 7/4\pi = 0.557\ 042\ 301\ \ldots . \qquad (5)$$

Recalling Count de Buffon's Needle Problem in which a unit needle was dropped on a grill of lines one unit apart, finding a probability $P = 2/\pi$ that a line was touched, it is not surprising that pi is in the denominator of (5).

(Mr. Rowe supplied the double definite integration steps between (3) and (4) as a handwritten appendix "because (a) they are routine, academic, and not worth publication, and (b) because it is impractical to type them." We have omitted the appendix because (a) it is routine, academic, and not worth publication, and (b) it is impractical to typeset. — Ed.)

JAN 4 Who plays where?

1. Andy dislikes the catcher.
2. Ed's sister is engaged to the second baseman.
3. The center fielder is taller than the right fielder.
4. Harry and the third baseman live in the same building.
5. Paul and Allen each won $20 from the pitcher at pinochle.
6. Ed and the outfielders play poker during their free time.
7. The pitcher's wife is the third baseman's sister.
8. All the battery and infield, except Allen, Harry, and Andy, are shorter than Sam.
9. Paul, Andy, and the shortstop lost $50 each at the race track.
10. Paul, Harry, Bill, and the catcher took a trouncing from the second baseman at pool.
11. Sam is involved in a divorce suit.
12. The catcher and the third baseman each have two children.
13. Ed, Paul, Jerry the center fielder, and the right fielder are bachelors.
14. The others are married.
15. The shortstop, the third baseman, and Bill each cleaned up $100 betting on the fight.
16. One of the outfielders is either Mike or Andy.
17. Jerry is taller than Bill.
18. Mike is shorter than Bill.
19. Each of them is heavier than the third baseman.

The following excellent solution is from Richard A. Baytor:

The problem is impossible exactly as printed, because it leads to a contradiction. However, replace the comma left out between "Jerry" and "the center fielder" in clue 13 and it is easily solved. I have drawn up a 9-x-9 matrix (*below*) to match the players with their positions. If a square has an X in it, then it is not possible according to the clue listed. An M means married, an N means not married, and a name in space means it must be him. These deductions are indicated by italic-face numbers, which are propagated across and down to indicate that this choice is no longer available.

Also solved by William J. Butler, Jr., Earl J. Rogers, Bill Harrington, Chuck Maison, Philip Garnick, Jens Eldrup-Jørgensen, Lester Glickman, Abraham Schwartz, Paul O. Kelly, Scott Davidson, R. Robinson Rowe, Winslow H. Hartford, John F. Chandler, Harry Zaremba, Neil E. Hopkins, W. Kelly Woods, Lee Laiterman, G. Michael Jaynes, Robert Weiss, David S. Landress, Robert M. Sutton, and the proposer, Anne Goetting. One reader, noticing the missing comma, decided that "a broad must have written" the problem; this letter was sent to *Technology Review* and when forwarded to me contained the pencilled comment, "We may be chubby but we're not broads." Right on!

JAN 5 Let S_1 be the sequence of polynomials in the variables tr A, tr A^2, tr A^3, . . . defined by the recurrence relations $S_0 = 1$ and

$$S_N = 1/N(S_{N-1}\,\mathrm{tr}\,A - S_{N-2}\,\mathrm{tr}\,A^2 + S_{N-3}\,\mathrm{tr}\,A^3 - \ldots + (-1)^{N-1} S_0\,\mathrm{tr}\,A^N).$$

(At this point, tr A, tr A^2, etc., should be considered simply abstract variables. For example, tr A^2 is *not* the square of tr A.) The first few polynomials are easily found to be:

$$S_0 = 1$$

$$S_1 = \mathrm{tr}\,A$$

$$S_2 = \frac{1}{2}(\mathrm{tr}\,A)^2 - \frac{1}{2}\mathrm{tr}\,A^2$$

$$S^3 = \frac{1}{6}(\mathrm{tr}\,A)^3 - \frac{1}{2}\mathrm{tr}\,A\,\mathrm{tr}\,A^2 + \frac{1}{3}\mathrm{tr}\,A^3$$

$$S_4 = \frac{1}{24}(\mathrm{tr}\,A)^4 - \frac{1}{4}(\mathrm{tr}\,A)^2\,\mathrm{tr}\,A^2 + \frac{1}{3}\mathrm{tr}\,A\,\mathrm{tr}\,A^3 + \frac{1}{8}(\mathrm{tr}\,A^2)^2 - \frac{1}{4}\mathrm{tr}\,A^4$$

Name	C	P	1	2	3	ss	lf	cf	rf
Andy	X1	*2*	*2*	*2*	Andy *2*	X9	X8	X8	X8
Allen	Allen 1	X5	*1*	*1*	*1*	*1*	X8	X8	X8
Bill	X10	*5*	*5*	X10	X15	X15	*4*	Bill *5*	*5**
Mike	X16, 8	X16, 8	X16, 8	X16, 8	X16, 8	X16, 8	*4*	*5*	Mike *5*
Jerry	X13, 12	X13, 12	*3*	Jerry *3*	X13, 12	*3*	*3*	X13	X13
N13									
Sam	X8	X8	X8	X8	X8	X8	Sam *4*	X13, 11	X13, 11
M11									
Ed	X13, 12	X13, 12	*6*	X2	X13, 12	Ed *7*	X6	X6	X6
N13									
Paul	X10	X5, 12, 13	Paul *6*	X10	X13, 12	X9	*4*	X13	X13
N13									
Harry	X10	Harry *8*	*6*	X10	X4	*7*	X8	X8	X8
	M12	M7		N2	M12			N13	N13

* Bill and Mike are the only ones who can be cf and rf. Clues 17, 18 tell us that Bill is taller, so Mike must be the right fielder (clue 3).

Now let "tr" denote the trace of a matrix, which is just the sum of the elements on the main diagonal. tr A^i means the trace of the matrix A^i, using matrix multiplication to produce A^i and then taking the trace of the result. If A is an N × N matrix, prove that its determinant is the value of S_N.

Our only response is from Scott S Brown:

Reduction 1: We may as well assume that A is a matrix over C. We can do this because the polynomial relation det A = S_N can hold for all points in R^{N^2} only if it is a formal identity between the entries of A. Reduction 2: We may as well assume that A is a diagonal matrix. If A is not diagonal, then there is an invertable matrix T and a diagonal matrix A′ such that $A = TA'T^{-1}$. Now

$$\det A = (\det T)(\det A')(\det T^{-1}) = (\det A)(\det A')(\det T)^{-1} = \det A'.$$

And using tr AB = tr BA,

$$\text{tr } A = \text{tr}\,[T(A'T^{-1})] = \text{tr}\,(A'T^{-1}T) = \text{tr } A'.$$

Proof for $A = \text{diag}\,(a_1, a_2, \ldots, a_N)$, we have $A^n = \text{diag}\,(a_1^n, a_2^n, \ldots, a_N^n)$, so $\text{tr } A^n = \Sigma a_i^n$.

Let $\Delta\,(n, e) = \sum a_{i_1} a_{i_2} \ldots a_{i_{s-1}} a_{i_s}^e a_{i_{s+1}} \ldots a_{i_n}$

where the sum is over
$1 \le i_1 < i_2 < \ldots < i_n \le N$ and
$1 \le s \le n$

Claim $S_n = \Delta\,(n, 1)$ for $n \ge 1$.

Proof by induction on n: For n = 1 the claim is clear. Assume that $S_k = \Delta\,(k, 1)$ for k = 1 to n − 1. Now

$$S_n = 1/n \cdot S_{n-1} \text{tr } A - S_{n-2} \text{tr } A^2 + \ldots + (-1)^{n-2} S_1 \text{tr } A^{n-1} + (-1)^{n-1}.$$

So $\text{tr } A^n = 1/n \cdot \Delta\,(n-1, 1)\,(\Sigma a_i) - \Delta\,(n-2, 1)\,(\Sigma a_i^2) + \ldots + (-1)^{n-2} \Delta\,(1, 1)\,\Sigma a_i^{n-1} + (-1)^{n-1}\,\Sigma a_i^n = 1/n \cdot [n\Delta\,(n, 1) + \Delta\,(n-1, 2)] - [\Delta\,(n-1,2) + \Delta\,(n-2,3)] + \ldots + (-1)^{n-2}\,[\Delta\,(2, n-1) + \Delta\,(1, n)] + (-1)^{n-1}\,\Delta\,(1, n) = \Delta\,(n, 1)$,

which proves the claim. Taking n = N in the claim shows $S_n = a_1 a_2 \ldots a_n = \det A$ and proves the result.

Better Late Than Never

1975 M/A5 Professor R. L. Bishop has a *complete* solution which effectively supercedes the published version. He writes:

Since your published solutions are only fragmentary, I venture to point out that my own technique yields all solutions. If the desired positive integers $a < b < c$ are added two at a time, let the sums be $A^2 < B^2 < C^2$. Further, let B = A + x and C = A + x + y. The general solution then calls for:

$$a = (A^2 - 2yA - y^2 - 2xy)/2$$
$$b = (A^2 + 2yA + y^2 + 2xy)/2$$
$$c = [A^2 + (2A + y)(2x + y) + 2x^2]/2$$

When one of these equations is satisfied by integers, subtraction proves that the others are also. Rewrite the first equation as:

$$A^2 - 2yA - y^2 = 2a + 2xy.$$

For each positive integer value of y there is an infinitely large family of solutions. It is required that y and A must be either both odd or both even. Secondly, for any given value of y and the minimum value of x = 1, it is necessary that

$$A > y + \sqrt{2}y(y + 1).$$

Finally, solutions then exist for all positive integer values of x, provided that

$$x < (A^2 - 2yA - y^2)/2y.$$

In contrast to the infinity of solutions for each value of y, your published solutions covered fully only the case of y = 1, partially the case of y = 2 (only for x = 2), and other cases not at all except for the reference to multiplying by squares.

On a related topic (cf., J/A4) Emmet J. Duffy points out that to find N positive distinct integers such that the sum of any N − 1 integers is a perfect square, one need only find N integers a, b, c, etc., whose squares, a^2, b^2, c^2, etc., add up to a sum S which is exactly divisible by N − 1, and where S/(N − 1) is greater than any of the squares. The desired N distinct positive integers are then

$$S/(N-1) - a^2,\ S/(N-1) - b^2,\ S/(N-1) - c^2, \text{ etc.}$$

The integers, a, b, c, etc., can be consecutive numbers if N is a multiple of 6, or a multiple of 6 to which 2 has been added, and the smallest number, a, is $(N-1)^2$.

JUN 4 Sidney Freidin, A. LeBlanc, and Avi Ornstein have responded.

O/N 1 Stanley G. Siegel has responded.

(Continued on p. 72)

John W. Devanney Renounces Review Offshore Oil Article

In the February, 1976, issue of the Technology Review *there was published an article, "Sharing the Offshore Oil Bonanza," reported to be an "adaptation by the editors of* Technology Review *of 'The O.C.S. Petroleum Pie,' by John W. Devanney, III, published in February, 1975, by the M.I.T. Sea Grant Program as Report Number MITSG 75-10, Index Number 75-310-Nme." Dr. Devanney is Associate Professor of Marine Systems in the M.I.T. Department of Ocean Engineering. The editors of* Technology Review *had originally requested from Dr. Devanney an article on this subject but chose to publish the adaptation of the Sea Grant Report in its place. Dr. Devanney believes that the adapted article as published is at significant variance from the work on which he has reported and is therefore misleading to the readers of the* Review. *The editors of the* Review *apologize to Dr. Devanney and to the* Review*'s readers if the article misrepresented the work of Dr. Devanney. We publish below a statement by Dr. Devanney suggesting corrections to the article and describing his view of the circumstances surrounding its publication.* — James A. Champy, Publisher

In the February issue of *Technology Review,* there appears an article, entitled "Sharing the Offshore Oil Bonanza," which purports to be an adaptation of my Sea Grant Report, "The O.C.S. Petroleum Pie." This article was published, without my knowledge, after I had ordered the editors not to print this erroneous and misleading version of my report and had withdrawn my own draft of an article because of the *Review*'s insistence on massive editorial changes.

The article as published is so completely at variance in style, lucidity, facts, and conclusions with both my draft and the original report that these differences, and their implications for me professionally, can only be appreciated by a complete reading of the article, my draft, and the original report. However, I will try to briefly outline the more glaring discrepancies.

1. Unit resource cost is not defined. This is absolutely basic to the whole argument. Unless the reader understands what is meant by cost to the nation, as opposed to the cost to the developer, the rest of the argument is meaningless.

2. The article states, "The amount of offshore oil is not yet certain, but deposits in the range of 60 to 80 billion barrels are likely." Nowhere in the report or my draft is there a statement that remotely resembles this line. On the contrary, there is a discussion of the great uncertainties inherent in predicting yet-to-be-discovered oil and the inadequacies of past predictions.

3. "Basically, *we* found the oil cost to be exceedingly low, even for the most difficult conditions and for small finds" (emphasis mine). This crucially important statement is just plain false. It appears nowhere in the original report nor my draft. The use of the first person clearly indicates it was written by me, yet it is the editors' fabrication. The actual statement in my draft was, "According to our analyses, the unit resource cost to the nation depends sharply on the size of the find. Further, for large finds, this unit resource cost can be as low as $2.00 or $3.00 per barrel, far below the current cost to the nation of landed O.P.E.C. crude." Both the report and the draft clearly make the point that the unit resource cost of a small find can easily be greater than the landed value of the crude.

4. The article as published is based on a mixture of the original report, in which the resource cost figures were based on computer runs made in early 1974 using pre-embargo cost data, and my draft in which the resource cost figures were based on mid-1975 computer runs and early-1975 cost data. Since no distinction is made, the article garbles the important effect of intervening inflation. The chart on page 45 (from my draft) does not support the 75-cents-per-barrel resource cost figure (from the original report) given on page 40 for very large finds. Since I was given no opportunity to review this article, a mislabeling of the figure on page 45 in my draft was reproduced in the article. The lower curve in this figure should be labeled "active water drive," the upper curve "pure gas drive."

5. ". . mid-range of U.S. Geological Survey estimates of offshore oil is 100 billion barrels." This statement is out of date as my draft indicated.

6. The whole comparison of various leasing systems is so hopelessly chopped up and disordered that it's almost impossible to comment on. What's left out is often much more important than what's put in. Further, the basic conclusion is simply false. The article states, ". . the M.I.T. analysis favored a system called 'percentage of excess profits bidding' for tracts on which the government has completed exploration." In fact, we never analyzed this alternative. Two of the six alternatives which we did compare were:
— Excess profits bidding prior to exploratory drilling.
— Public exploratory drilling followed by bonus bidding.
We gave a narrow nod to the former *only if* tax laws could be changed to define taxable profits in net present value terms.

7. Nowhere in the report is there a statement that the argument for accelerated leasing depends on the "cost of capital continuing to rise." The actual statement in the report is, ". . from the point of view of national income, as long as one believes the real cost of capital will be greater than the real rate of inflation in foreign crude prices, there is an extremely strong argument for greatly expanded leasing."

In addition there are a number of important changes in connotation. Example: The report and my draft state that the savings associated with offshore oil will not be "passed on" to the consumer in the form of lower prices. The editors changed "not passed on" to "cannot be measured by." One need not be completely paranoid to regard this as something more than innocent obfuscation. The sensationalist title is another example.

In total, the article is rife with factual errors and a serious misrepresentation of the report on which it is based. The order and continuity of the argument has been completely destroyed. At the same time by:
— writing for the most part in a pseudo-original report style complete with the use of the first person,
— lifting whole paragraphs from the original report without direct citation, and
— listing my name with those of the feature article authors on the back cover,
it leaves the definite impression that it was authored by me or at the very least has been published with my approval.

In fact, I ordered the editor not to publish this "version" of my report and was unaware that he was going to publish it anyway by simply deleting my name as author. I was given no opportunity to append a disclaimer. Thus, this incorrect, incoherent jumble of words holds me up to ridicule from any reader knowledgeable in the area and in fact any reader who appreciates a closely-reasoned, well-written argument.

Since this article makes no attempt to distinguish those portions which are lifted directly from the original report from those which have been introduced by the editors or grossly altered, it constitutes, in part, the grossest form of plagiarism and, in the remainder, serious misrepresentation of my position. I have been injured professionally and no doubt economically. Much more importantly, over the last four years I had gained a position of respect with both the proponents and opponents of offshore oil. Both sides have attempted to use me as a supporting authority. I was in an unusual position to influence federal policy in the multi-billion dollar decisions the government must make with respect to offshore oil. This article may have destroyed that position.

I have asked the Provost of M.I.T. to form a committee to investigate the facts of this incident and to consider whether further safeguards against the *Review*'s abusing of its special relationship with the Institute faculty are in order. He has agreed to do so. Also, the *Review* has agreed to furnish, free of charge, a copy of my draft to any reader requesting it. I invite all readers who are sincerely interested in the decisions facing the nation with respect to offshore oil to do so.

John W. Devanney III
Cambridge, Mass.

An Institute Informant

The Editors' digest of recent and current concerns at the Massachusetts Institute of Technology

Research Notes

Cultivating Human Skin Cells
Human skin cells, which until now could not be grown artificially, are now being cultivated at M.I.T. The trick is to use irradiated fibroblasts — the underskin material — so that the fibroblast cells do not multiply in the cell-growing culture. When thus freed from competition, a single skin cell can grow into a colony of several thousand in about three weeks, says Dr. Howard Green, Professor of Cell Biology.

Dr. Green thinks the discovery opens the way to important new research on skin cell growth and differentiation — and perhaps also to new methods in clinical care. He speculates that laboratory-grown skin cells may be used to study the effects of viruses such as those which cause warts, to study the behavior of diseased skin cells, and to test drugs. And he suggests that large quantities of skin may in the future be grown for skin grafts.

The "J" Particle: Puzzling as Ever
The "J" particle, whose discovery a year ago triggered the finding of a whole family of similar particles and some 2,000 theoretical papers by authors trying to explain the data, is still not understood — a misfit in the world of subatomic particles.

Many physicists proposed that the "J" particle is composed of a hypothetical subparticle called a "charmed quark" and its antimatter equivalent, the "charmed anti-quark." But Professor Samuel C. C. Ting, the original discoverer of the "J" particle, says some recent data from research at Brookhaven National Laboratory point in exactly the opposite direction.

Research since the "J" particle was discovered has established:
— The "J" particle is a bound system of a particle and an anti-particle; it has many excited states, and their pattern is similar to that of the positronium, the anti-particle of the electron.
— The "J" particle is definitely a hadron. (Subatomic particles are divided into hadrons, including the proton and neutron; and leptons, including the electron. Hadrons respond to all three of the fundamental forces in nature — the electromagnetic force, the "weak interaction," and the nuclear force; leptons respond only to the first two.)

The work by Dr. Ting and Professor Ulrich J. Becker during the past year has involved analysis of "more than 50 million examples of data. . . . It is by far the most comprehensive attempt to investigate the new particles, . . . 1,000 times more sensitive than other work in Europe and the U.S.," says Dr. Ting. But he and his colleagues remain as puzzled as ever.

Measuring the Temperature of Fusion
A narrow, powerful beam of infrared radiation is being adapted to measure the temperature — up to 80 million degrees Kelvin — in thermonuclear fusion machines. Dr. Daniel R. Cohn of the Francis Bitter National Magnet Laboratory proposes that Thomson scattering will cause the frequency of the infrared in a laser beam to be shifted slightly as it encounters the high-temperature plasma ions; measuring this shift will give information on both temperature and purity of the plasma. A carbon-dioxide laser is used to excite methyl fluoride, producing the required infrared radiation; a 10-kilowatt beam is now available. The ultimate goal is a one-megawatt beam, and a 200-kilowatt beam may be produced soon.

Factors in Planning

What influences the choices people make about where they want to live, and businesses about where to locate?

Good answers to these questions could help planners and governments when they seek to influence the direction and form of future growth, think Professor Jerome Rothenberg and three colleagues in the Department of Economics. Hence their effort to develop a computer-based model which incorporates data on business activities, housing supply, demand, and quality, environmental attributes, and management and economic policies in the many areas of the Boston metropolitan region. They hope the model when completed can be used to show cause-and-effect correlations between policies and development.

Students Seek New Electric Resources

Alternative energy resources are the challenge — for the second time in three years — for college engineering students entering the 1976-77 Student Competitions on Relevant Engineering. The final testing event of S.C.O.R.E.'s E.R.A. II competition will be at Washington State University in June, 1977; by then perhaps as many as 1,000 college students will have worked in teams to develop electric power generating equipment using solar energy, biological wastes, wind, or coal.

The idea of S.C.O.R.E.'s new competition is threefold, says Mark Radtke, S.C.O.R.E. President whose office is at M.I.T.:
— To supplement engineering education with hardware design and fabrication projects which give students real-world experience.
— To contribute to the solution of the world energy problem through student innovation.
— To increase public awareness of the energy problem and of the innovative concepts which student teams can develop to help solve it.

S.C.O.R.E. is a student-run, nonprofit corporation established by the engineering college community to promote student competitions. Its first undertaking, in 1971, was a competition in urban vehicle design; then came Students Against Fires (1973-74) and Energy Resources Alternatives I (1974-75) (*see "Alternative Energy: Living on Our Interest"* in Technology Review *for December, 1975*). E.R.A. II concentrates on electric power generation, says Mr. Radtke, "because we feel that this is now the real challenge for the alternative energy field."

On comsoles, talking computers, robot secretaries, telesafaris, infomania, communications satellites and the hope that we are not alone in the universe — Mr. Clarke foresees an exciting future for communications.

Arthur C. Clarke

Communications in the Second Century of the Telephone

Man is the communicating animal; he demands news, information, entertainment, almost as much as food. In fact, as a functioning human being, he can survive much longer without food — even without water! — than without information, as experiments in sensory deprivation have shown. This is a truly astonishing fact; one could construct a whole philosophy around it.

So any major advance in communications capability that can be conceived can be realized in practice, and that same advance will come into widespread use just as soon as it is practicable. Often sooner; the public can't wait for "state of the art" to settle down. Remember the first clumsy phonographs, radios, tape recorders? And would you believe the date of the first music broadcast? It was barely a year after the invention of the telephone! On April 2, 1877, a "telegraphic harmony" apparatus in Philadelphia sent "Yankee Doodle" to sixteen loudspeakers — well, soft-speakers — in New York's Steinway Hall. Alexander Graham Bell was in the audience, and one would like to know if he complimented the promoter — his now forgotten rival, Elisha Gray, who got to the Patent Office just those fatal few hours too late. . .

Gray was not the only one to be caught out by the momentum of events. When news of the telephone reached England through Cyrus Field's undersea telegraphic cable, the chief engineer of the Post Office was asked whether this new Yankee invention would be of any practical value. He gave the forthright reply: "No, sir. The Americans have need of the telephone — but we do not. We have plenty of messenger boys."

Before you laugh at this myopic Victorian, please ask yourself this question: would you, exactly a hundred years ago, ever dream that the time would come when this primitive toy would not only be in every home and every office, but would be the essential basis of all social, administrative and business life in the civilized world? Or that one day there would be approximately one instrument for every ten human beings on the planet?

Now, the telephone is a very simple device, which even the 19th century could readily mass produce. In fact, one derivative of the carbon microphone must be near the absolute zero of technological complexity: you can make a working — though hardly hi-fi — microphone out of three carpenter's nails, one laid across the other two to form a letter H.

The extraordinary — nay, magical — simplicity of the telephone allowed it to spread over the world with astonishing speed. When we consider the very much more complex devices of the future, is it reasonable to suppose that they too will eventually become features of every home, every office? Well, let me give you another cautionary tale.

The Comfortable Comsole

In the early 1940s, the late John W. Campbell — editor of *Astounding Stories*, and undoubtedly the most formidable imagination ever to be flunked at M.I.T. — poohpoohed the idea of home television. He refused to believe that anything as complex as a TV receiver could ever be made cheap and reliable enough for domestic use.

Public demand certainly disposed of that prophecy. Home TV became available in the Early Neo-Electronic Age — that is, even *before* the solid-state revolution. So let us take it as axiomatic that complexity is no bar to universality. Think of your pocket computers and march fearlessly into the future . . . trying to imagine the ideal, ultimate communications system — the one that would fulfill all possible fantasies.

Since no holds are barred, what about telepathy? Well, I don't believe in telepathy — but I don't *dis*believe in it either. Certainly some form of electronically-assisted mental linkage seems plausible; in fact, this has already been achieved in a very crude form, between men and computers, through monitoring of brain waves. However, I find that *my* mental processes are so incoherent, even when I try to focus and organize them, that I should be very sorry for anyone at the receiving end. Our superhuman successors, if any, may be able to cope; indeed, the development of the right technology might force such an evolutionary advance. Perhaps the best that *we* could manage would be the sharing of emotional states, not the higher intellectual processes. So radio-assisted telepathy might merely lead to some interesting new vices — admittedly, a long-felt want.

Let's stick, therefore, to the recognized sense channels, of which sound and sight are by far the most important. Although one day we will presumably develop transducers for all the senses, just because they are there, I suspect that the law of diminishing returns will set in rather rapidly after the "feelies" and "smellies." These may have

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This article was taken from an address by Mr. Clarke at the "Convocation on Communications in Celebration of the Centennial of the Telephone," sponsored by American Telephone and Telegraph Co. and the Massachusetts Institute of Technology.

Drawings by Jerry Dadds

". . . there are no fundamental scientific obstacles, even to interstellar travel. Though Nobel Laureate Dr. Edward Purcell once rashly remarked that starships should stay on the cereal boxes, where they belonged – that's exactly where moonships were, only 30 years ago. . ."

some limited applications for entertainment purposes, as anyone who was pulverized by the movie *Earthquake* may agree. (Personally, I'm looking forward to the epic *Nova*, in which the theater's heating system is turned on full blast in the final reel. . .)

The basic ingredients of the ideal communications device are, therefore, already in common use even today. The standard computer console, with keyboard and visual display, plus hi-fi sound and TV camera, will do very nicely. Through such an instrument (for which I've coined the ugly but perhaps unavoidable name "comsole" — communications console) one could have face-to-face interaction with anyone, anywhere on earth, and send or receive any type of information. I think most of us would settle for this, but there are some other possibilities to consider.

For example: what about *verbal* inputs? Do we really need a keyboard? I'm sure the answer is "Yes." We want to be able to type out messages, look at them, and edit them before transmission. We need keyboard inputs for privacy, and quietness. A *reliable* voice recognition system, capable of coping with accents, hangovers, ill-fitting dentures and the "human error" that my late friend HAL, the computer from *2001*, complained about, represents something many orders of magnitude more complex than a simple alpha-numeric keyboard. It would be a device with capabilities, in a limited area, at least as good as those of a human brain.

Yet assuming that the curves of the last few decades can be extrapolated, this will certainly be available sometime in the next century. Though most of us will still be tapping out numbers in 2001, I've little real doubt that well before 2076 you will simply say to your comsole: "Get me Bill Smith". Or if you *do* say: "Get me 212-345-5512," it will answer, "Surely you mean 212-345-5521." And it will be quite right.

Now a machine with this sort of capability — a robot secretary, in effect — could be quite expensive. *It doesn't matter.*

Contrary to the edicts of Madison Avenue, the time will come when it won't be necessary to trade in last year's model. Eventually, everything reaches its technological plateau, and thereafter the only changes are in matters of style. This is obvious when you look at such familiar domestic objects as chairs, beds, tables, knives, forks. Oh, you can make them of plastic or fiberglass or whatever, but the basic design rarely alters.

It took a few thousand years to reach these particular plateaus; things happen more quickly nowadays even for much more complex devices. The bicycle took about a century; radio receivers half that time. This is not to deny that marginal improvements will go on indefinitely, but after a while all further changes are icing on a perfectly palatable cake. You may be surprised to learn that there are electrical devices that have been giving satisfactory service for half a century or more. The other day someone found an Edison carbon filament lamp that has apparently never been switched off since it was installed. And until recently, there were sections of Atlantic cable that had been in service for a full century!

Now, it's hard to see how a properly designed and constructed solid-state device can ever wear out. It should have something like the working life of a diamond, which is adequate for most practical purposes. So when we reach this state of affairs, it would be worth investing more in a multi-purpose home communications device than in an automobile. It could be handed on from one generation to the next — as was once the case with a good watch.

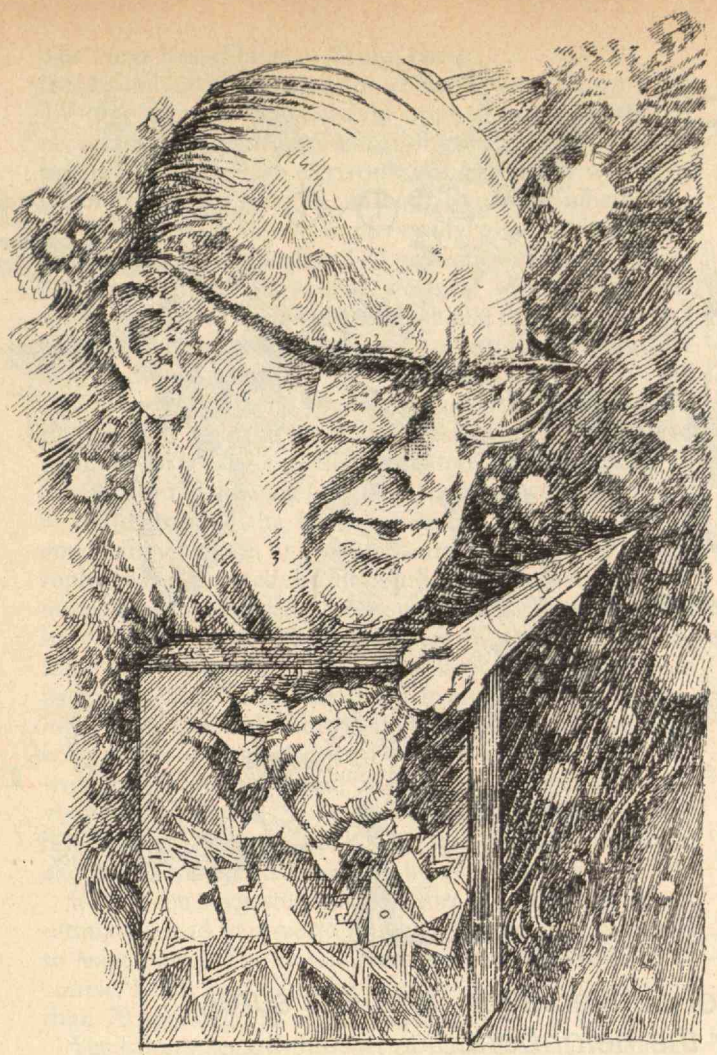
Plugging in to the Future

It has been obvious for a very long time that such audio-visual devices could complete the revolution started by the telephone. We are already approaching the point when it will be feasible — not necessarily desirable — for those engaged in what is quaintly called "white-collar" jobs to do perhaps 95 per cent of their work without leaving home. Of course, few of today's families could survive this, but for the moment let's confine ourselves to electronic, not social, technology.

Many years ago I coined the slogan: "Don't commute — communicate!" Apart from the savings in travel time (the *real* reason I became a writer is that I refuse to spend more than 30 seconds moving from home to office) there would be astronomical economies in power and raw materials. Compare the amount of hardware in communications systems, as opposed to railroads, highways and airlines. And the number of kilowatt hours you expend on the shortest journey would power several lifetimes of chatter, between the remotest ends of the earth.

Obviously, the home comsole would handle most of today's first-class mail; messages would be stored in its memory waiting for you to press the playback key whenever you felt like it. Then you would type out the answer — or alternatively call up the other party for a face-to-face chat.

Fine, but at once we have a serious problem — the already annoying matter of time zones. They are going to



become quite intolerable in the electronic global village — where we are all neighbors, but a third of us are asleep at any given moment. The other day I was woken up at 4:00 a.m. by the London *Daily Express*, which had subtracted 5½ hours instead of adding them. I don't know what I said, but I doubt if my views on the Loch Ness Monster were printable.

The railroads and the telegraph made time zones inevitable in the 19th century; the global telecommunications network of the 21st may abolish them. It's been suggested, at least half seriously, that we'll have to establish a Common Time over the whole planet — whatever inconvenience this may cause to those old-fashioned enough to gear themselves to the day-night cycle.

During the course of the day — whatever *that* may be — you will use the home comsole to call your friends and deal with business, exactly as you use the telephone now — with this difference: you'll be able to exchange any amount of tabular, visual or graphical information. Thus if you're an author, you'll be able to wave that horrid page-one type in front of your delinquent editor on Easter Island, or wherever he lives. Instead of spending hours hunting for non-existent parts numbers, engineers will be able to *show* their supplier the broken dohickey from the rotary discombobulator. And we'll be able to see those old friends of a lifetime, whom we'll never again meet in the flesh.

Which raises an interesting problem. One of the great advantages of Mr. Bell's invention is that you can converse with people *without* their seeing you, or knowing where you are, or who is with you. A great many business deals would never be consummated, or even attempted, over a video circuit; but perhaps they are deals that shouldn't be, anyway. . .

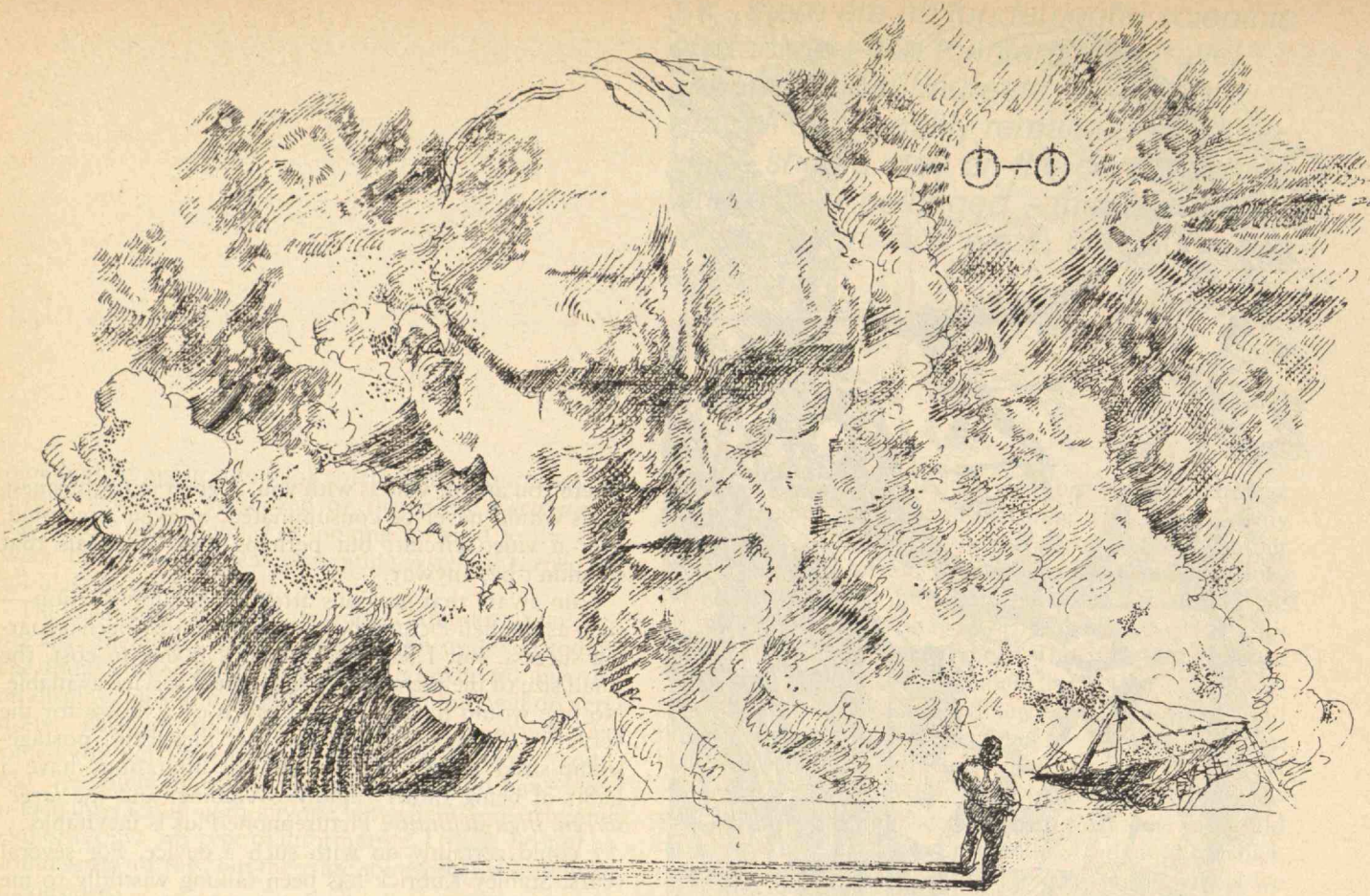
I am aware that previous attempts to supply vision — such as the Bell Picturephone — have hardly been a roaring success. But I feel sure that this is due to cost, the small size of the picture, and the limited service available. No one would have predicted much of a future for the very first "Televisors," with their flickering, postage-stamp-sized images. Such technical limitations have a habit of being rather rapidly overcome, and the *large-screen, high-definition* Picturephone-Plus is inevitable.

I could certainly do with such a device. For several years, Stanley Kubrick has been talking wistfully to me about another space project. But there's an insoluble problem — I won't leave my home in Sri Lanka for more than a couple of weeks a year, and Stanley refuses to get into an airplane. We may both be too old, or too lazy, before the arrival of home comsoles makes another collaboration possible. So the present backwardness of electronics has spared the world another masterpiece like *2001: A Space Odyssey*.

Clearly, when we do have two-way vision, there will have to be some changes in protocol. You can't *always* pretend to your wife that the camera has broken down again. . . Incidentally, some of the changes that would be produced in a society totally orientated to telecommunications have been well discussed by a promising local writer, in a novel called *The Naked Sun*. The author's full name escapes me at the moment, but I believe it begins with "Isaac."

Infomaniacs Rejoice!

The possibilities of the comsole as an entertainment and information device are virtually unlimited; some of them, of course, are just becoming available, as an adjunct to the various TV subscription services. At any moment one should be able to call up all the news headlines on the screen, and expand any of particular interest into a complete story at several levels of thoroughness — all the way, let us say, from the *Daily News* to the *New York Times* . . . I hate to think of the hours I have wasted, listening to radio news bulletins — for some item that never turned up. Nothing is more frustrating — as will be confirmed by any Englishmen touring the United States during a Test Match, or any American in England during the World Series (how did it get that ridiculous name?). For the first time, it will be possible to have a news service



"The galaxy must be an absolute Babel of conversation, and it is surely only a matter of time before we can hear the neighbors."

with immediacy, selectivity, *and* thoroughness.

The electronic newspaper, apart from all its other merits, will also have two gigantic ecological plusses. It will save whole forests for posterity; and it will halve the cost of garbage collection. This alone might be enough to justify it, and to pay for it.

Like many of my generation, I became a news addict during World War II. Even now, it takes a definite effort of will for me *not* to switch on the hourly news summaries, and with a truly global service one could spend every waking minute monitoring the amusing, crazy, interesting and tragic things that go on around this planet. I can foresee the rise of even more virulent forms of news addiction, resulting in the evolution of a class of people who can't bear to miss anything that's happening, anywhere, and spend their waking hours glued to the console. I've even coined a name for them — Infomaniacs.

Continuing in this vein, I used to think how nice it would be to have access, in one's own home, to all the books and printed matter, all the recordings and movies, all the visual arts of mankind. But would not many of us be completely overwhelmed by such an embarassment of riches, and solve the impossible problem of selection by selecting nothing? Every day I sneak guiltily past my set of the *Great Books of the Western World*, most of which I've never even opened. . . What would it *really* be like to have the Library of Congress — *all* the world's great libraries — at your fingertips? Assuming, of course, that your fingertips were sufficiently educated to handle the problem of indexing and retrieval. I speak with some feeling on this subject, because for a couple of years I had the job of classifying and indexing everything published in the physical sciences, in all languages. If you can't find what you're looking for in *Physics Abstracts* for 1949-51, you'll know who to blame.

With the latest techniques, it would be possible to put the whole of human knowledge into a shoe box. The problem, of course, is to get it out again; anything misfiled would be irretrievably lost. Another problem is to decide whether we mass-produce the shoe boxes, so that every family has one — or whether we have a central shoe box linked to the home with wide-band communications.

Probably we'll have both, and there are also some interesting compromises. Years ago I invented something that I christened, believe it or not, the *Micropaedia Brittanica*. My *Micropaedia* would be a box about the size of an ordinary hard-cover book, with a display screen and alpha-numeric keyboard. It would contain, in text and pictures, *at least* as much material as a large encyclopaedia plus dictionary.

However, the main point of the electronic *Brittanica* would not be its compactness — but the fact that, every few months, you could plug it in, dial a number, and have it up-dated overnight. . . Think of the saving in wood pulp and transportation that this implies!

The Next Best Thing to Being There . . .

It is usually assumed that the comsole would have a flat TV-type screen, which would appear to be all that is necessary for most communications purposes. But the ultimate in face-to-face electronic confrontation would be when you could not tell, without touching, whether or not the other person was physically present; he or she would appear as a perfect 3-D projection. This no longer appears fantastic, now that we have seen holographic displays that are quite indistinguishable from reality. So I am sure that this will be achieved some day; I am not sure how badly we need it.

What *could* be done, even with current techniques, is to provide 3-D — or at least widescreen Cinerama-type — pictures for a single person at a time. This would need merely a small viewing booth and some clever optics, and it could provide the basis for a valuable educational-entertainment tool, as Dennis Gabor, inventor of holography, has suggested. But it could also give rise to a new industry — personalized television safaris. When you can have a high-quality cinema display in your own home, there will certainly be global audiences for specialized programs with instant feedback from viewer to cameraman. How nice to be able to make a trip up the Amazon, with a few dozen unknown friends scattered over the world, with perfect sound and vision, being able to ask your guide questions, suggest detours, request closeups of interesting plants or animals — in fact, sharing everything except the mosquitoes and the heat!

It has been suggested that this sort of technology might ultimately lead to a world in which no one ever bothered to leave home. The classic treatment of this theme is, of course, E. M. Forster's *The Machine Stops*, written more than 70 years ago as a counterblast to H. G. Wells.

Yet I don't regard this sort of pathological, sedentary society as very likely. "Telesafaris" might have just the opposite effect. The customers would, sooner or later, be inspired to visit the places that really appealed to them. . . mosquitoes notwithstanding. Improved communications will promote travel for *pleasure*; and the sooner we get rid of the other kind, the better.

The Moveable Information Feast

So far, I have been talking about the communications devices in the home and the office. But in the last few decades we have seen the telephone begin to lose its metal umbilical cord, and this process will accelerate. The rise of walkie-talkies and Citizen's Band radio is a portent of the future.

The individual wrist-watch telephone through which you can contact anyone, anywhere, will be a mixed blessing which, nevertheless, very few will be able to reject. In fact, we may not have a choice; it is all too easy to imagine a society in which it is illegal to switch off your receiver, in case the Chairman of the People's Cooperative wants to summon you in a hurry. . . But let's not ally ourselves with those reactionaries who look only on the *bad* side of every new development. Alexander Graham Bell cannot be blamed for Stalin, once aptly described as "Genghis Khan with a telephone."

It would be an *underestimate* to say that the wrist-watch telephone would save tens of thousands of lives a year. Everyone of us knows of tragedies — car accidents on lonely highways, lost campers, overturned boats, even old people at home — where some means of communication would have made all the difference between life and death. Even a simple emergency S.O.S. system, whereby one pressed a button and sent out a HELP! signal, would be enough. This is a possibility of the immediate future; the only real problem — and, alas, a serious one — is that of false alarms.

Now, the invariably forgotten accessory of the wrist-watch telephone is the wrist-watch telephone *directory*. Considering the bulk of that volume for even a modest-sized city, this means that our personal transceivers will require some sophisticated information-retrieval circuits, and a memory to hold the few hundred most-used numbers. So we may be forced, rather quickly, to go the whole way, and combine in a single highly portable unit not only communications equipment, but also something like today's pocket-calculators, plus data banks, plus information processing circuits. It would be a constant companion, serving much the same purpose as a human secretary. In a recent novel I called it a "Minisec." In fact, as electronic intelligence develops, it would provide more and more services, finally developing a personality of its own, to a degree which may be unimaginable today.

Except, of course, by science fiction writers. In his brilliant novel, *The Futurological Congress*, Stanislaw Lem gives a nightmare cameo which I can't get out of my mind. He describes a group of women sitting in complete silence — while their handbag computers gossip happily to one another. . .

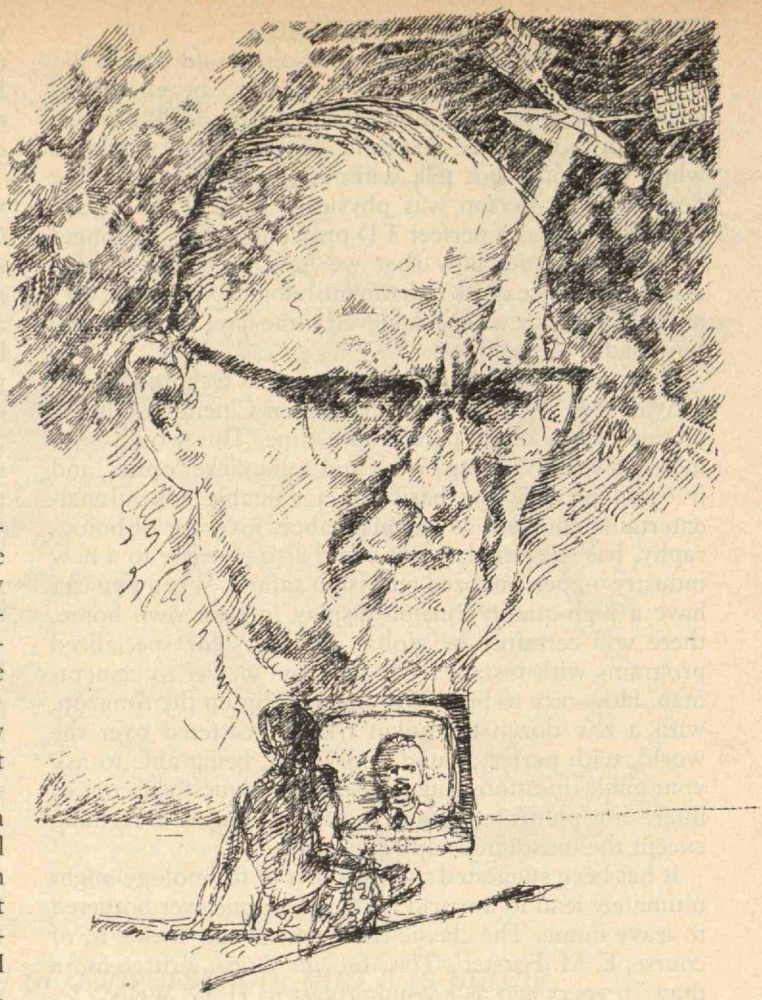
Tiptoeing Through the Spectrum

At this point, before I lose all credibility with the hairy-knuckled engineers who have to produce the hardware, I'd better do a once-over-lightly of the electromagnetic spectrum. This is, I think, unique among our natural resources. We've been exploiting it for less than one lifetime, and are now polluting much of it to the very maximum of our ability. But if we stopped using it tomorrow, it would be just as good as new, because the garbage is heading outwards at the speed of light. . . Too bad this isn't true of the rest of the environment.

Do we have enough available bandwidth for a billion personal transceivers, even assuming that they aren't all working at once? As far as the home equipment is concerned, there is no problem, at least in communities of any size. The only uncertainty, and a pretty harrowing one to the people who have to make the decisions, is how quickly coaxial cables are going to be replaced by glass fibers, with their million-fold greater communications capability. Incidentally, one of the less glamorous occupations of the future will be mining houses for the rare metal, copper, buried inside them by our rich ancestors. Fortunately, there is no danger that we shall ever run out of silica. . .

But I would also suggest that optical systems, in the infrared and ultraviolet, have a great future not only for fixed, but even for *mobile*, personal communications. They may take over some of the functions of present-day transistor radios and walkie-talkies — leaving the radio bands free for services which can be provided in no other way. The fact that opticals have only very limited range, owing to atmospheric absorption, can be turned to major advantage. You can use the same frequencies — and *what* a band of frequencies! — millions of times over — as long as you keep your service areas 10 or 20 kilometers apart.

It may be objected that light waves won't go round corners, or through walls. Elementary, my dear Watson. We simply have lots of dirt cheap — because they are



made from dirt! — optical wave guides and light pipes deliberately leaking radiation all over the place. Some would be passive, some active. Some would have very low-powered optical-to-radio transducers in both directions, to save knocking holes in walls, and to get to awkward places. In densely populated communities one would always be in direct or reflected sight of some optical transmitter or repeater. But we must be careful how we use the ultraviolet. People who talked too much might get sunburned. . .

When you are cycling across Africa, or drifting on a balsa-wood raft across the Pacific, you will of course still have to use the radio frequencies — say the one to ten thousand megahertz bands, which can accomodate at least ten million voice circuits. This number can be multiplied many times by skillful use of satellite technology. I can envisage an earth-embracing halo of low-altitude, low-powered radio satellites, switching frequencies continually so that they provide the desired coverage in given geographical regions. And N.A.S.A. has recently published a most exciting report on the use of the very large (kilometer-square!) antennas we will soon be able to construct in space. These would permit the simultaneous use of myriads of very narrow beams which could be focused on individual subscribers carrying receivers which could be mass-produced for about $10. I rather suspect that our long-awaited personal transceiver will be an adaptive, radio-optical hybrid, actively hunting the electromagnetic spectrum in search of incoming signals addressed to it.

The Electronic Drug?

One of the functions of science fiction is to serve as an early warning system. In fact, the very act of description may prevent some futures, by a kind of exclusion principle. Far from predicting the future, science fiction often *exorcises* it. At the very least, it makes us ask ourselves: "What kind of future do we really want?" No other type of literature poses such fundamental questions, at any rate explicitly.

The marvellous toys that we have been discussing will simply remain toys, unless we use them constructively and creatively. Now, toys are all right in the proper place; in fact they are an essential part of any childhood. But they should not become mere distractions — or ways of drugging the mind to avoid reality.

We have all seen unbuttoned beer-bellies slumped in front of the TV set, and transitorized morons twitching down the street, puppets controlled by invisible disk jockeys. These are not the highest representatives of our culture; but, tragically, they may be typical of the near future. As we evolve a society orientated towards information, and move away from one based primarily on manufacture and transportation, there will be millions who cannot adapt to the change. We may have no alternative but to use the lower electronic arts to keep them in a state of drugged placidity.

For in the world of the future, the sort of mindless labor that has occupied 99 per cent of mankind, for much more than 99 per cent of its existence, will of course be largely taken over by machines. Yet most people are bored to death without work — even work that they don't like. In a workless world, therefore, only the highly educated will be able to flourish, or perhaps even to survive. The rest are likely to destroy themselves and their environment out of sheer frustration. This is no vision of the distant future; it is already happening, most of all in the decaying cities.

So perhaps we should not despise TV soap operas if, during the turbulent transition period between our culture and real civilization, they serve as yet another opium for the masses. *This* drug, at any rate, is cheap and harmless, serving to kill time — for those many people who like it better dead.

Communicate to Educate

When we look at the manifold problems of our age, it is clear that the most fundamental one — from which almost all others stem — is that of ignorance. And ignorance can be banished only by communication, in the

"We are now in the early stages of a battle for the mind . . . of the human race, a battle which will be fought 36,000 kilometers above the equator."

widest meaning of the word.

The best educational arrangement, someone once remarked, consists of a log with a teacher at one end and a pupil at the other. Unfortunately there are no longer enough teachers, and probably not enough logs, to go around.

Now, one thing that electronics can do rather well is to multiply teachers. As you doubtless know, at this very moment a most ambitious and exciting social experiment is taking place in India, where N.A.S.A.'s ATS-6 satellite is broadcasting educational programs to several thousand villages. ATS-6 is the only communications satellite in existence powerful enough to transmit signals that can be picked up on an ordinary TV set, augmented by a simple parabolic dish, like a large umbrella made of wire mesh.

Thanks to the extraordinary generosity of the Indian Space Research Organization, which flew in six engineers and half a ton of equipment, I have a five-meter satellite antenna on the roof of my Colombo house, now renamed "Jodrell Bank East." Since the experiment started on August 1, 1975, I have thus been in the curious position of having the only TV set in Sri Lanka. It's been fascinating to watch the programs; even though I don't understand Hindi, the messages of family planning, hygiene, agricultural techniques and national unity come across loud and clear.

Though it is impossible to put a value on such things, I believe that the cost of this experiment will be trivial compared with the benefits. And the ground segment is remarkably cheap, in terms of its coverage. Would you believe 4,000 people round one TV set? Or a 3-meter-diameter village antenna — made of *dried mud*?

Of course, there are some critics — as reported recently by Dr. Yash Pal, the able and energetic Director of the Indian Space Application Centre:

"In the drawing rooms of large cities," he says, "you meet many people who are concerned about the damage one is going to cause to the integrity of rural India by exposing her to the world outside. After they have lectured you about the dangers of corrupting this innocent, beautiful mass of humanity, they usually turn round and ask: 'Well, now that we have a satellite, when are we going to see some American programs?' Of course they themselves are immune to cultural domination or foreign influence."

I'm afraid that cocktail party intellectuals are the same everywhere. Because *we* frequently suffer from the modern scourge of information pollution, we find it hard to imagine its even deadlier opposite — information starvation. For any outsider, however well-meaning, to tell an Indian villager that he would be better off without access to the world's news, entertainment, *and knowledge*, is an obscene impertinence, like the spectacle of a fat man preaching the virtues of fasting to the hungry.

Unfortunately, on July 31, 1976, the one-year experiment will end; ATS-6 will crawl back along the equator and return to the United States. Originally, it was hoped to launch *two* satellites; last summer I saw the three-quarters completed ATS-7, sitting mothballed at the Fairchild plant. No one could raise the $10 million necessary to finish it, or hijack one of the Air Force's numerous Titan 3-Cs to get it into orbit.

And so in a few months' time, millions of people who have had a window opened on marvellous new worlds of culture and education will have it slammed in their faces again. There will be some heart-rending scenes in the villages, when the cry goes up, however unfairly, "The Americans have stolen our satellite!" Useless to explain, as the frustrated viewers start to refill their six-to-nine p.m. time slot with baby-making, that it was only through the initiative and generosity of the United States that the satellite was loaned in the first place. . . The Ugly American will have struck again.

Yet I hope that this noble experiment is just the curtain-raiser to a truly global educational satellite system. Its cost would be one or two dollars per student, per *year*. There could be few better investments in the future health, happiness and peace of mankind.

I don't wish to get too much involved in the potential — still less the politics — of communications satellites, because they can take care of themselves, and are now multiplying rapidly. The world investment in satellites and ground stations now exceeds a billion dollars, and is increasing almost explosively. After years of delay and dithering, the United States is at last establishing *domestic* satellite systems; the U.S.S.R. has had one for almost a decade. At first, the Soviet network employed *non*-synchronous satellites, moving in an elongated orbit that took them high over Russia for a few hours of every day. However, they have now seen the overwhelming advantages of stationary orbits, and several of their comsats are currently fixed above the Indian Ocean. Some are designed for TV relaying to remote parts of the Soviet Union, and I've gently hinted to my friends in Moscow that perhaps *they* could fill the breach when ATS-6 goes home. . .

We are now in the early stages of a battle for the mind — or at least the eyes and ears — of the human race, a battle which will be fought 36,000 kilometers above the

equator. The preliminary skirmishes have already taken place at the United Nations, where there have been determined attempts by some countries to limit the use of satellites which can beam programs from space directly into the home, thus bypassing the national networks. Guess who is scared. . .

As a matter of fact, I tried to frighten the United States with satellites myself, back in 1960, when I published a story in 1960 in *Playboy* about a Chinese plot to brainwash innocent Americans with pornographic TV programs. Perhaps "frighten" is not the correct verb, and in these permissive days such an idea sounds positively old-fashioned. But in 1960 the first regular comsat service was still five years in the future, and this seemed a good gambit for attracting attention to its possibilities.

United States of Earth

Fortunately, in this area there is an excellent record of international cooperation. Even countries who hate each other's guts work together through the International Telecommunications Union, which sets limits to powers and assigns frequencies. Eventually, some kind of consensus will emerge, which will avoid the worst abuses.

A major step towards this was taken on August 20, 1971, when the agreement setting up INTELSAT (the International Telecommunications Satellite Organization) was signed at the State Department. I would like to quote from the address I gave on that occasion:

"I submit that the eventual impact of the communications satellite upon the whole human race will be at least as great as that of the telephone upon the so-called developed societies.

"In fact, as far as real communications are concerned, there are as yet no developed societies; we are all still in the semaphore and smoke-signal stage. And we are now about to witness an interesting situation in which many countries, particularly in Asia and Africa, are going to leapfrog a whole era of communications technology and go straight into the space age. They will never know the vast networks of cables and microwave links that this country has built at such enormous cost both in money and in natural resources. The satellites can do far more and at far less expense to the environment. . .

". . .I believe that the communications satellites can unite mankind. Let me remind you, that, whatever the history books say, this great country was created a little more than a hundred years ago by two inventions. Without them, the United States was impossible; with them, it was inevitable. Those inventions were, of course, the railroad and the electric telegraph.

"Today we are seeing on a global scale an almost exact parallel to that situation. What the railroads and the telegraph did here a century ago, the jets and the communications satellites are doing now to all the world. . ."

And the final result — whatever name we actually give to it — will be the United States of Earth.

The Space Barrier

I would like to end with some thoughts on the wider future of communications — communications beyond the earth. And here we face an extraordinary paradox, which in the centuries to come may have profound political and cultural implications.

For the whole of human history, up to that moment one hundred years ago when the telephone was invented, it was impossible for two persons more than a few meters apart to interact in real time. The abolition of that apparently fundamental barrier was one of technology's supreme triumphs; today we take it for granted that men can converse with each other, and even see each other, wherever they may be. Generations will live and die, always with this godlike power at their fingertips.

Yet this superb achievement will be ephemeral; before the next hundred years have passed, our hard-won victory over space will have been lost, never to be regained.

On the Apollo voyages, for the first time, men traveled more than a light-second away from earth. The resulting two-and-a-half second round-trip communications delay was surprisingly unobtrusive, but only because of the dramatic nature of the messages — and the discipline of the speakers. I doubt if the average person will have the self-control to talk comfortably with anyone on the moon.

And beyond the moon, of course, it will be impossible. We will never be able to converse with friends on Mars, even though we can easily exchange any amount of information with them. It will take at least three minutes to get there, and another three minutes to receive a reply.

Anyone who considers that this is never likely to be of much practical importance is taking a very short-sighted view. It has now been demonstrated, beyond reasonable doubt, that in the course of the next century, we could occupy the entire solar system. The resources in energy and material are there; the unknowns are the motivation — and our probability of survival, which may indeed depend upon the rate with which we get our eggs out of this

one fragile planetary basket.

We would not be here, talking about the future, unless we were optimists. And in that case we must *assume* that eventually very large populations will be living far from earth — light-minutes and light-hours away, even if we colonize only the inner solar system. However, space colony advocate Freeman Dyson has argued with great eloquence that planets aren't important, and the real action will be in the cloud of comets out beyond Pluto, a light-*day* or more from earth.

And looking further afield, it is now widely realized that there are no *fundamental* scientific obstacles even to interstellar travel. Though Nobel Laureate Dr. Edward Purcell once rashly remarked that star-ships should stay on the cereal boxes, where they belonged — that's exactly where moonships were, only 30 years ago. . .

So the finite velocity of light will, inevitably, divide the human race once more into scattered communities, sundered by barriers of space and time. We will be as one with our remote ancestors, who lived in a world of immense and often insuperable distances, for we are moving out into a universe vaster than all their dreams.

Are There Others?

But it is, surely, not an empty universe. No discussion of communications and the future would be complete without reference to the most exciting possibility of all — communications with extra-terrestrial ingelligence. The galaxy must be an absolute Babel of conversation, and it is surely only a matter of time before we can hear the neighbors. They already know about us, for our sphere of detectable radio signals is now scores of light-years across. Perhaps even more to the point — and more likely to bring the precinct cops hurrying here as fast as their paddy-wagon can travel — is the fact that several microsecond-thick shells of x-ray pulses are already more than ten light-years out from earth, announcing to the universe that, somewhere, juvenile delinquents are detonating atom bombs.

Plausible arguments suggest that our best bet for interstellar eavesdropping would be in the 1000-Megahertz, or 30 centimeter, region of the spectrum. The N.A.S.A./Stanford/Ames *Project Cyclops* report, which proposed an array of several hundred large radio telescopes for such a search, recommended a specific band about 200 Megahertz wide — that lying between the hydrogen line (1420 MHz) and the lowest OH line (1,662 MHz). Dr. Bernard Oliver, who directed the *Cyclops* study, has waxed poetic about the appropriateness of *our* type of life seeking its kind in the band lying between the disassociation products of water — the "water-hole."

Unfortunately, we may be about to pollute the water-hole so badly that it will be useless to radio astronomers. The proposed MARESAT and NAVSTAR satellites will be dunked right in the middle of it, radiating so powerfully that they would completely saturate any *Cyclops*-type array. Barney Oliver tells me: "Since the *Cyclops* study, additional reasons have become apparent for expecting the water-hole to be our contact with the mainstream of life in the galaxy. The thought that we, through our ignorance, may blind ourselves to such contact and condemn the human race to isolation appalls us."

I hope that the next World Administrative Radio Conference, when it meets in 1979, will take a stand on this matter. The conflict of interest between the radio astronomers and the communications engineers will get more and more insoluble, until, as I suggested many years ago, we move the astronomers to the quietest place in the solar system — the center of the lunar farside, where they will be shielded from the radio racket of earth by 3,500 kilometers of solid rock. But *that* answer will hardly be available before the next century.

Whatever the difficulties and problems, the search for extra-terrestrial signals will continue. Some scientists fear that it will not succeed; others fear that it *will*. It may already have succeeded, but we don't yet know it. Even if the pulsars *are* neutron stars — so what? They may still be artificial beacons, all broadcasting essentially the same message: "Last stop for gas this side of Andromeda."

More seriously, if the decades and the centuries pass, with no indication that there is intelligent life elsewhere in the universe, the long-term effects on human philosophy will be profound — and may be disastrous. Better to have neighbors we don't like, than to be utterly alone. For that cosmic loneliness could point to a very depressing conclusion — that intelligence marks an evolutionary dead-end. When we consider how well — and how *long* — the sharks and the cockroaches have managed without it, and how badly we are managing *with* it, one cannot help wondering if intelligence is an aberration like the armor of the dinosaurs, dooming its possessors to extinction.

No, I don't *really* believe this. Even if the computers we carry on our shoulders are evolutionary accidents, they can now generate their own programs — and set their own goals.

For we can now say, in the widest possible meaning of the phrase, that the purpose of human life is information processing. I have already mentioned the strange fact that men can survive longer without water than without information. . .

And therefore the real value of all the devices we have been discussing is that they have the potential for immensely enriching and enlarging life, by giving us more information to process — up to the maximum number of bits per second that the human brain can absorb.

I am happy, therefore, to have solved one of the great problems the philosophers and theologians have been haggling over for several thousand years. You may, perhaps, feel that this is rather a dusty answer, and that not even the most inspired preacher could ever found a religion upon the slogan: "The purpose of life is information processing." Indeed, you may even retort: "Well, what is the purpose of information processing?"

I'm glad you asked me that. . .

Arthur C. Clarke is author of numerous popular works of science fiction and science fact, including the book and movie *2001: A Space Odyssey*, and his latest novel, *Imperial Earth* (Harcourt, Brace, Jovanovich, 1975). He is also credited with conceiving the idea of the communications satellite. Says Mr. Clarke, "Back in 1943, as an extremely callow officer in the Royal Air Force, I was given a mysterious assignment to a fog-shrouded airfield at the southwestern tip of England.

"It turned out I was to work with an eccentric group of Americans from something called the Radiation Laboratory of the Massachusetts Institute of Technology. They were led by a bright young physicist named Luis Alvarez, who had invented a radar device that, for a change did something useful. It could bring down an aircraft in one piece, instead of several.

"Luis' brainchild provided me with the peaceful environment, totally insulated from all the nasty bombings and invasions happening elsewhere, which allowed me to work out the principles of communications satellites in the spring of 1945."

Anthony C. Picardi
William W. Seifert
M.I.T.

A Tragedy of the Commons in the Sahel

The tragedy of the commons concept was first introduced by Garrett Hardin in a discussion of the world population problem. He likened the earth's natural resources to a common pasture on which everyone grazes his livestock according to his own desires. Since there is no control over how many animals each individual grazes, the common pasture is inevitably destroyed. The immutable logic of individual self-interest dictates that if an additional cow is placed on the pasture, the individual derives the total benefit from the cow, while all users of the pasture must share each additional cow's overgrazing. Therefore each individual's benefits outweigh his costs and everyone overuses the pasture. Thus, Hardin concluded, when commonly held resources are exploited according to individual self-interest, the resources will be overexploited and destroyed by the same people who benefit from them.

The tragedy of the commons syndrome is beginning to show up more and more as world population grows. In almost all cases of crowding of public facilities — parks, highways, and open spaces where people are allowed free access — congestion results. Each additional individual receives the full benefit of his use of the facility, while all of his neighbors share the additional crowding. For example, people originally settle in suburbs to escape congestion and high real estate prices and taxes, and to attain the amenities of nearby open space. As more people get the same idea, quiet suburbia becomes a mere extension of the crowded city.

Pollution is frequently another tragedy of the commons syndrome, in which the common media of air and water are overexploited. Although efforts are being made to deal with air and water pollution, legislators have seldom come to grips with the equity issues implicit in this generic social problem. The pollution solution (in the U.S.) is typically to set and enforce standards for air and water quality, expecting individual firms and municipalities to meet certain standards of purity. As more people move into the city, however, the cost of removing each additional fraction of the pollution load increases. The city raises its taxes, companies their prices, and the electric utility its rates. This additional cost is shared by everyone in the town. Thus the new resident in an already crowded area gains the full benefit of his move, while everyone must share the costs of his additional load on the environment.

The tragedy of the commons syndrome is most obvious and pathetic when it occurs in the overuse of renewable biological resources such as fisheries, or grazing lands. Such biological resources have a maximum sustainable yield level, a balance at which they may be exploited indefinitely with no reduction of productivity. Fishing or cropping above this level depletes the breeding stock and destroys the resource.

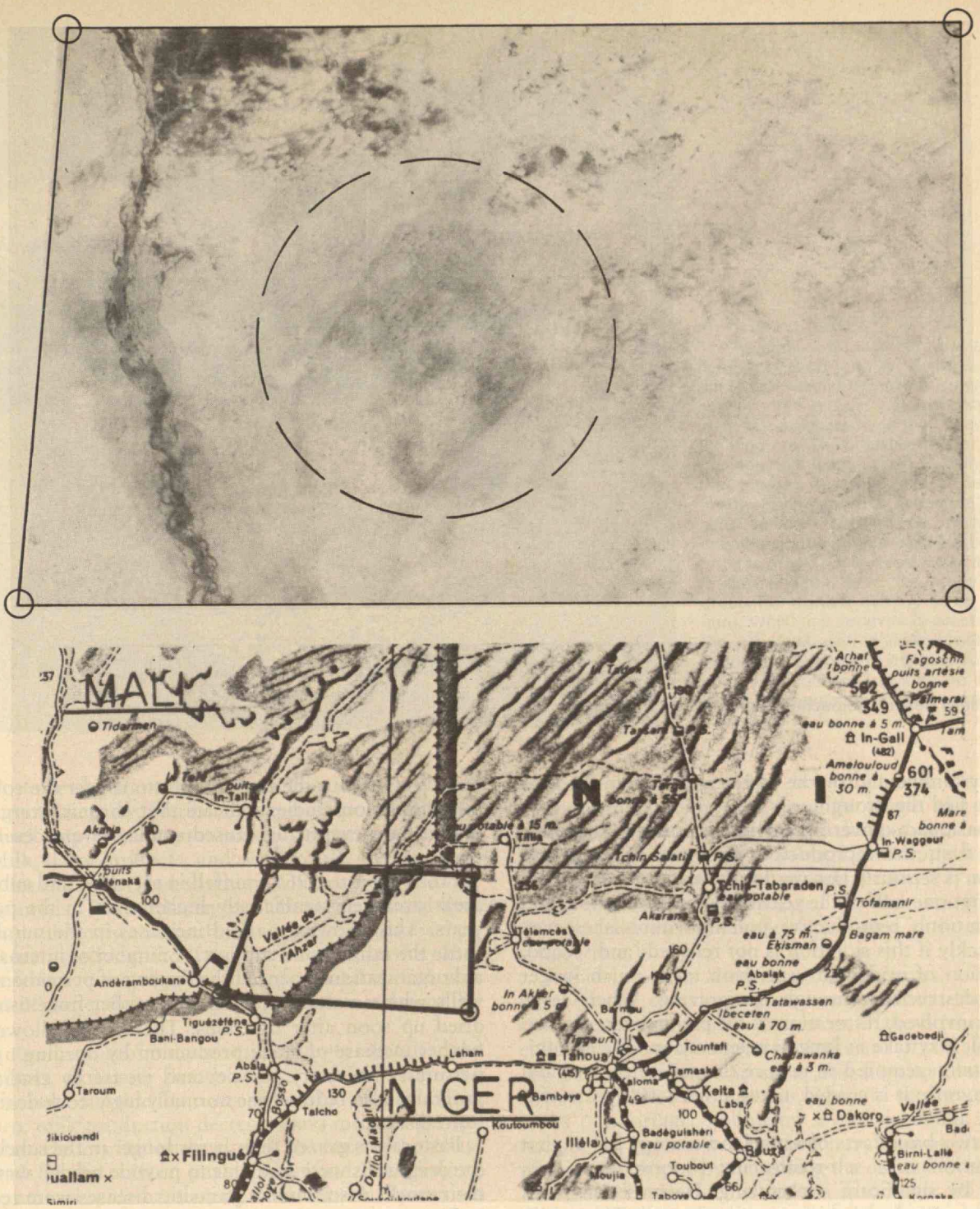
In sub-saharan Africa, the tragedy of the commons syndrome has worked a disaster. World attention has focused on the human and ecological tragedy which left 50 to 80 per cent of the livestock dead, and uncounted thousands of herdsmen destitute and starving in refugee camps.

In 1973 and 1974, soon after the last disastrous drought, we began to study the causes of this tragedy of the commons firsthand. We used the data collected and the impressions which emerged from discussions with African leaders, aid organizations, and people at research institutes, and through observation of the area, to create a computer simulation model relating the interactions among the ecosystem, livestock herds and the human population. The purpose of the model was to test long-term policies for the recovery and restoration of the sahel (sa-hail▲) areas so that aid organizations might work effectively to help the region's recovery and development. The study reveals the underlying dynamic response of the pastoral system to the variety of aid approaches proposed for the sahels.

A limited geographical area, about the size of Kentucky, was used as the quantitative data base for the model. This area, the pastoral zone of Niger north of Tahoua, has an annual rainfall between 100 and 500 mm. The rain falls only in June, July, August, and rainfalls are higher to the south, away from the Sahara Desert. The area was populated by about 120,000 Fulani and Tuareg herdsmen in 1966. Now the population has shrunk to around 90,000. The nomadic and semi-nomadic herdsmen of the area derive their livelihood almost totally from animal husbandry. The thin, sandy, sahel soils support only degraded grasslands, some woody shrubs, thorn trees and coarse ephemeral plants.

The Dynamics of Pastoralism

Sudden collapse of the human and animal populations of the sahel came concurrently with the rapid destruction of the rangeland. This destruction, called desertification, indicates that the range can no longer produce adequate green forage because of soil erosion and the plants' losses of their regenerative abilities. The population growth rates, stock growth rates, rainfall pattern, herd losses and extent of desertification from 1920 to the present all contributed to the tragedy in the sahel. Sudden population decreases *(see figure on page 45)* in the early 1970s were

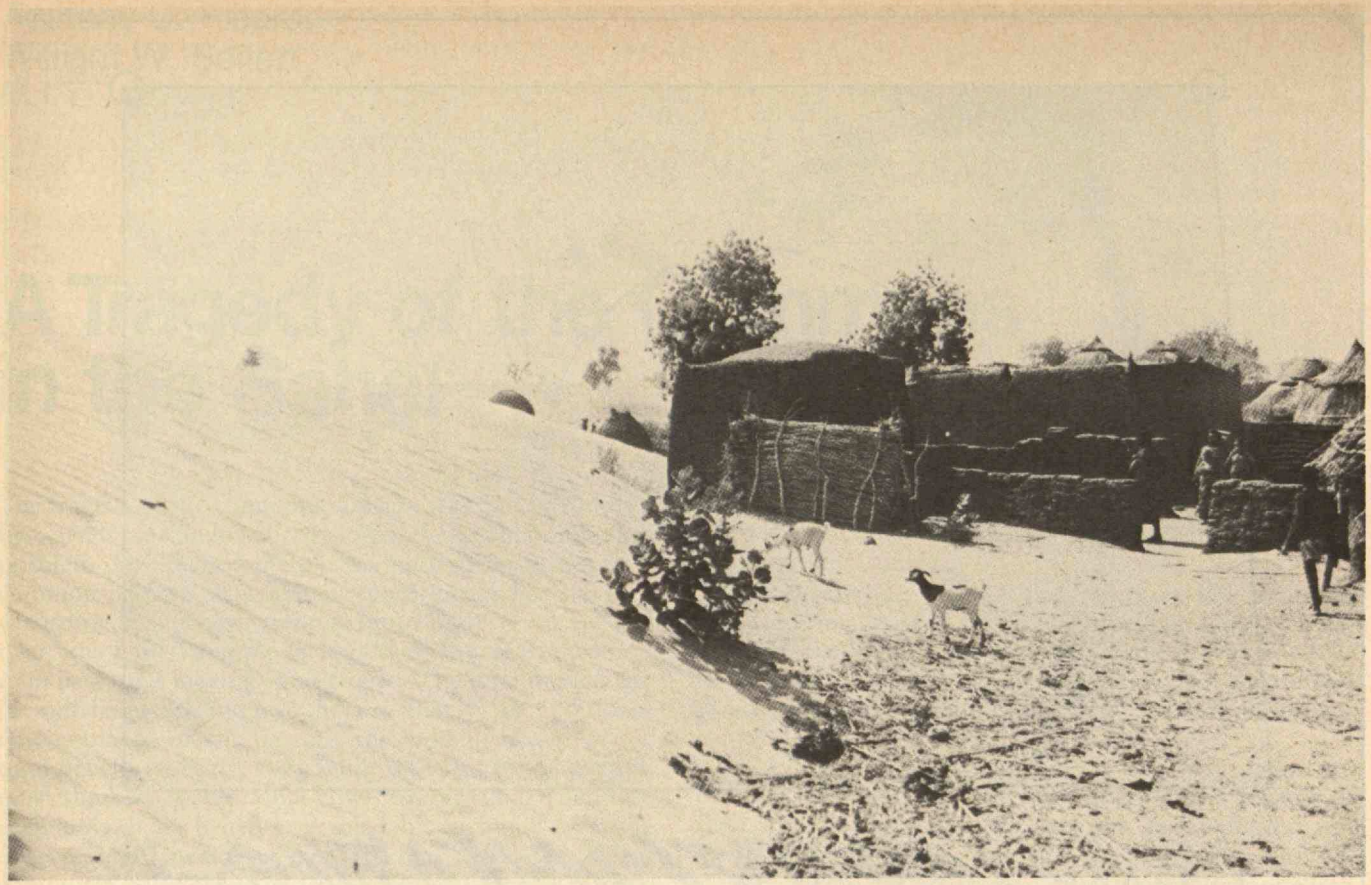


An E.R.T.S. satellite photograph of a ranch on the Niger-Mali border indicates the positive effects of controlled grazing in this arid environment. The photograph, taken at the end of the rainy season in 1973, shows that even minimal control for a period of five years makes a perceptible difference in the cover of vegetation over the range.

Grazing control, enforced by a barbed wire fence which surrounds the range, involved reducing the number of animals living on the range during the drought, and importing supplemental feed so that the cattle would use up no more than half the natural forage growing on the land. The ranch shows as the dark hexagonal area within the dotted circle above.

This relatively small area experienced the same drought conditions as the rest of the sahel, convincing evidence that the drought was exacerbated by over-use of the land by people and animals.

Enforcing such control over the entire sahel would interfere with and perhaps destroy forever the nomadic cultures of the Tuareg and Fulani herdsmen. These tribes and their herds follow the rains through the range each year. At present, such control of herds and land is well beyond their means.



The relentless desert encroaches upon a sahelian village.

caused by famine and by the large exodus from the area as people fled the drought.

Two basic facts govern the dynamics of arid rangeland ecology: first, the reproductive potential of rangeland vegetation is seriously impaired if the yearly cropping exceeds about one-half of the yearly foliage production, and the vegetation's reproductive potential diminishes even more quickly if this situation is not relieved; and second, regeneration of arid land vegetation takes much longer than its destruction through overgrazing. Where large areas are involved, restoration of the plant cover, even on fertile soil, may take as long as a generation. The ecological succession required to restore the soil to the original condition, once it is eroded, takes at least 100 years, if it occurs at all.

These two basic facts of rangeland ecology tell us that desertification is a self-reinforcing process once it is triggered by significant overgrazing. Decreases in plant cover allow wind and rain to erode the soil. The soil in turn loses fertility and water-holding abilities. Fewer plants are produced in succeeding years and, if the herds of zebu cattle and goats are not reduced, these plants are even more severely overgrazed. Plant cover is further reduced since perennial plants can no longer support the large root systems necessary to reach the water table, and annuals can no longer produce enough seeds to re-sow themselves. Either a drought or a buildup in grazing pressure can trigger the initial critical reduction in plant cover.

Computer simulations and historical accounts agree that chronic overgrazing in the sahel began in the early 1960s. When the last drought began in 1969, overgrazing increased rapidly and desertification became widespread. But even without the last drought to trigger the collapse, our simulation studies indicate that chronic overgrazing would have eventually caused similar severe desertification.

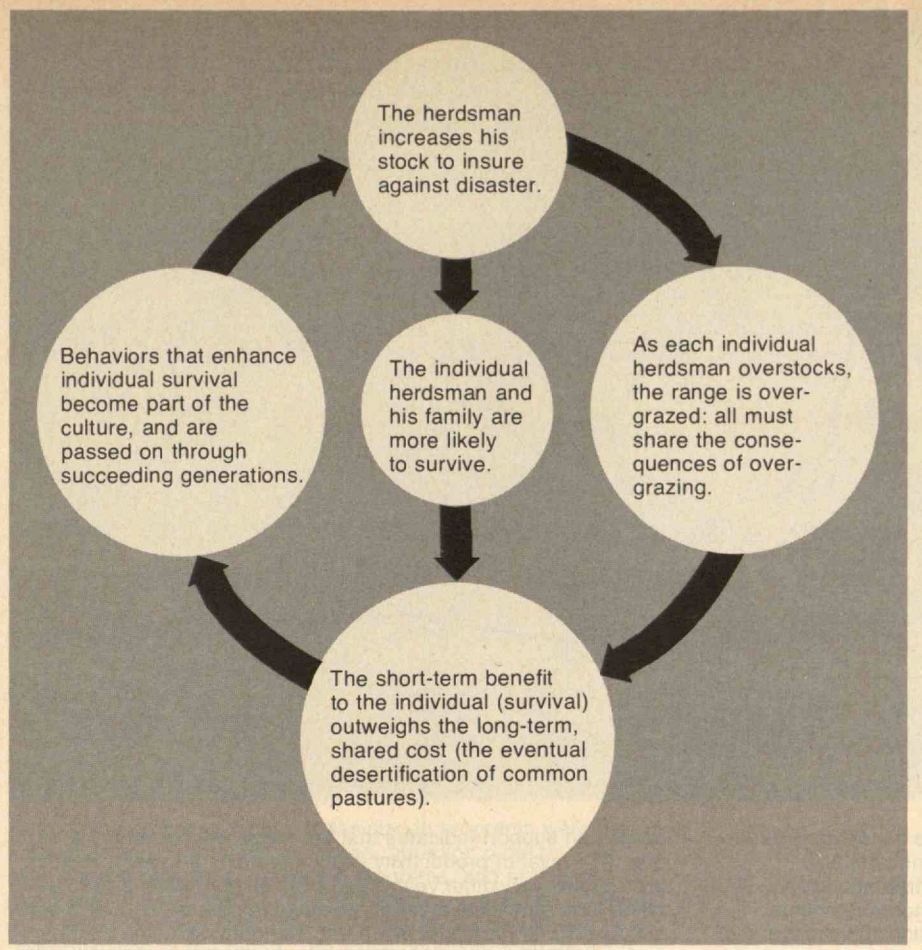
From 1955 to 1965, rainfall in the sahel and subdesert areas averaged significantly higher than in the past 53 years. This allowed marked increases in the number of cattle the range could support. A number of international aid organizations financed the digging of permanent deep wells where watering points were either nonexistent or dried up soon after the rains. These wells allowed the further increase of stock production by opening up new pastures. Veterinary services and tse-tse fly eradication programs also reduced the normally high stock death rate from disease.

Pastoralists grazed their herds longer in the sahel, once the deep wells were available to provide needed water for their stock. Also, human parasitic diseases were reduced in frequency as more potable water from permanent deep wells was made available. Thus both the human and animal populations grew rapidly in the last two decades, because of technological interventions in the pastoral system and the generally favorable rainfall conditions.

Economic and social forces also determine how pastoralists manage their herds. Our discussion of pastoral economics will show the widespread effect of both weather and ecology upon the herdsman's management decisions, and how, in turn, his management decisions affect the ecosystem.

Living in the Subdesert

Pastoralism is by far the predominant way of life in the sahel. Only in years of good rainfall can dry-land millet



The herdsmen of the sahel have evolved a number of short-term individual survival strategies which have allowed them to survive through the dry season from year to year, but which damage the ecosystem in the long run. Thus, traditional herd management leads to overstocking and, in the long run, desertification, as depicted above. Each individual herdsman in the sahel serves himself and his family best by maintaining the largest possible herd in order to provide milk, to sell for goods in the market, and to use as "insurance" should drought or disease destroy some of the herd. While this behavior is practical from the individual point of view, it tends to encourage overuse of the common grazing land. The feedback loops above illustrate this classic example of the tragedy of the commons.

and vegetables be planted, and even then such gardening is a marginal activity. Herdsmen depend upon milk from their stock to provide approximately 35 per cent of their diet. Milk, dairy products, and occasionally livestock are traded for the millet and sorghum which supply the rest of their needs. The herdsmen eat little meat. Instead livestock are sold in the market for mats, sandals, calabashes, tools, tents, clothing, etc. In short, survival in the sahel requires them to maintain a milk supply and a minimum number of cattle, sheep, and goats for each member of the family.

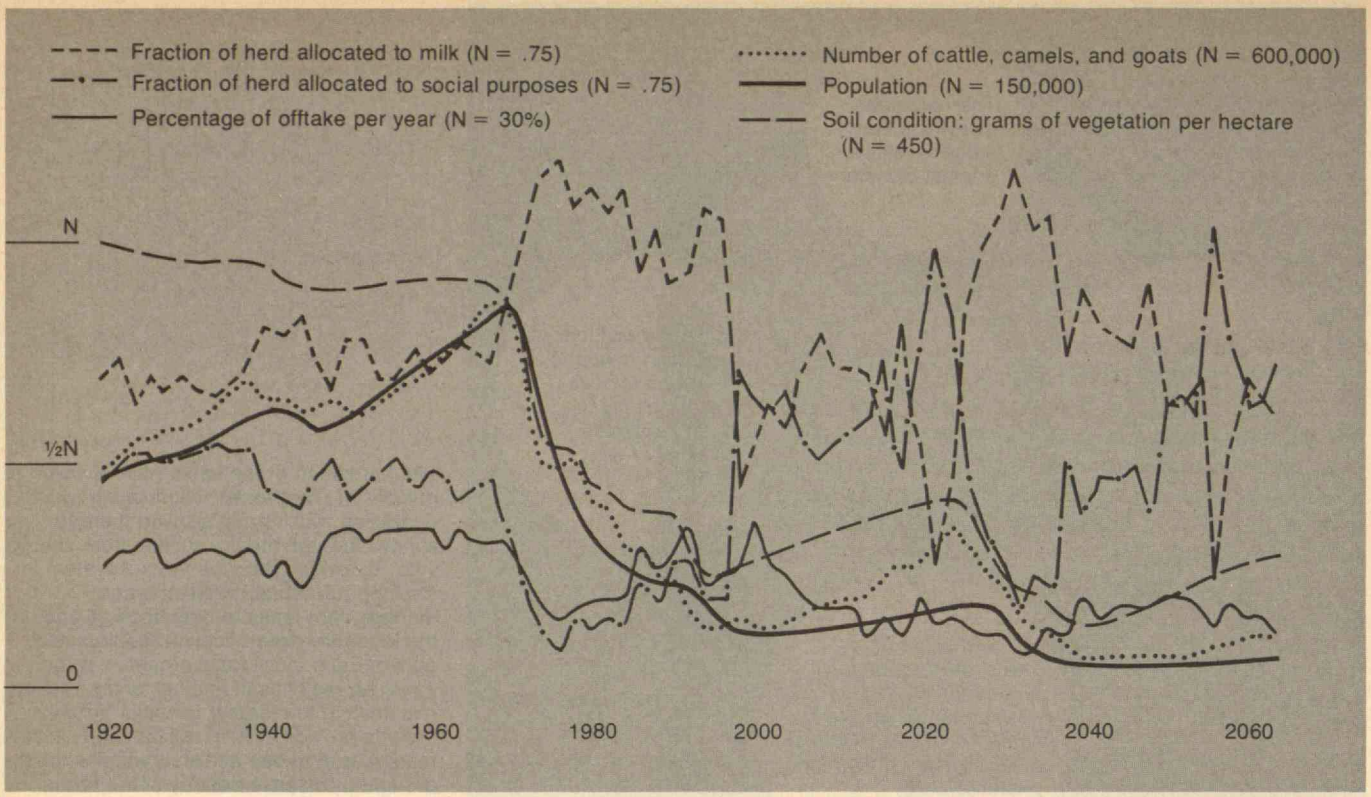
The need to maintain a milk supply dictates the herdsman's economic priorities. As conditions in the sahel worsen, pasture becomes exhausted, fewer calves are born, milk production decreases and more cattle die. The relatively less important uses of the herd — purchasing goods in the market, paying taxes and fines, buying tea, sugar, and spices, and using stock for social purposes — are then sacrificed in favor of milk production. Thus rainfall, range conditions, and population growth fundamentally affect the pastoral economy. Inadequacies in milk production cause the herdsman to sell fewer cattle each year, lowering the offtake rates, and adjust herd usage so as to eliminate these inadequacies. The system is self-regulating, responding automatically to environmental conditions and long-term population pressures.

Our computer plot of offtake rate shows this economic causality *(see figure on page 46)*. In the drought years of the 1940s and 1970s when the offtake decreased, more cattle were allocated for milk production, and fewer for social purposes. The per capita wealth also decreased, because in poor years the herdsmen cannot afford to replace goods as they wear out. Thus the herdsman's priorities determine his characteristic behavior given a set of environmental conditions. (During the height of a drought, herdsmen characteristically try to dump dying animals on the market in an effort to salvage something from their starving herds. Since these animals die anyway and since prices are markedly depressed in this situation, the phenomenon was not explicitly included in the simulated offtake rate.)

Surplus stock is used to purchase wives, for gifts in name-giving ceremonies, as compensation for serious crimes, and for gifts to daughters at the birth of a first child. It is the most important indicator of social status in the pastoral culture. Stock is also kept in "savings" to loan to relatives or simply as excess to be drawn upon in times of shortage. Following severe droughts and their accompanying famines, herdsmen try to avoid recurrence of this catastrophe by increasing the desired level of stock for these "insurance" purposes. The figure on page 00 shows this as a steep rise in the herd allocated for social purposes after each drought.

The pastoralists' annual migrations are yet another strategy to reduce the most fearsome hazard, losing the entire herd. Herdsmen make these seasonal migrations in order to exploit fresh pastures which have been replenished by the rains, and later to graze their herds on post-harvest residues in agricultural areas south of the sahel.

Herdsmen avoid going too far into the more humid agricultural zones or entering them too soon after the seasonal rains for fear that their zebu cattle will become infected with trypanosomiasis (sleeping sickness). The zebu is a hardy, drought-resistant, tropical bovine, which reaches a full growth weight of about 300 kg. and can



The chart reflects the actual experience in the sahel from 1920 to the present, and simulates sahelian conditions until 2070, assuming no interventions occur. The most dramatic aspect of these data is the sudden collapse of the human and animal populations concurrent with the rapid destruction of the rangeland. The continuing decrease in the numbers of people and animals the range can support indicates that the range will not return to its pre-1974 level of productivity within the next 100 years. Results are plotted every other year. Yearly rainfall from 1920 to 1973 was taken from statistical records, whereas rainfall beyond 1973 was simulated with the same mean and standard deviation as the historical data.

produce milk for up to ten years. However, it is quite susceptible to trypanosomiasis, if bitten by the parasite-carrying tse-tse fly prevalent in tropical Africa. Some anthropologists have gone so far as to suggest that a certain amount of overgrazing is done deliberately in order to maintain arid conditions and prevent the northward spread of the tse-tse fly.

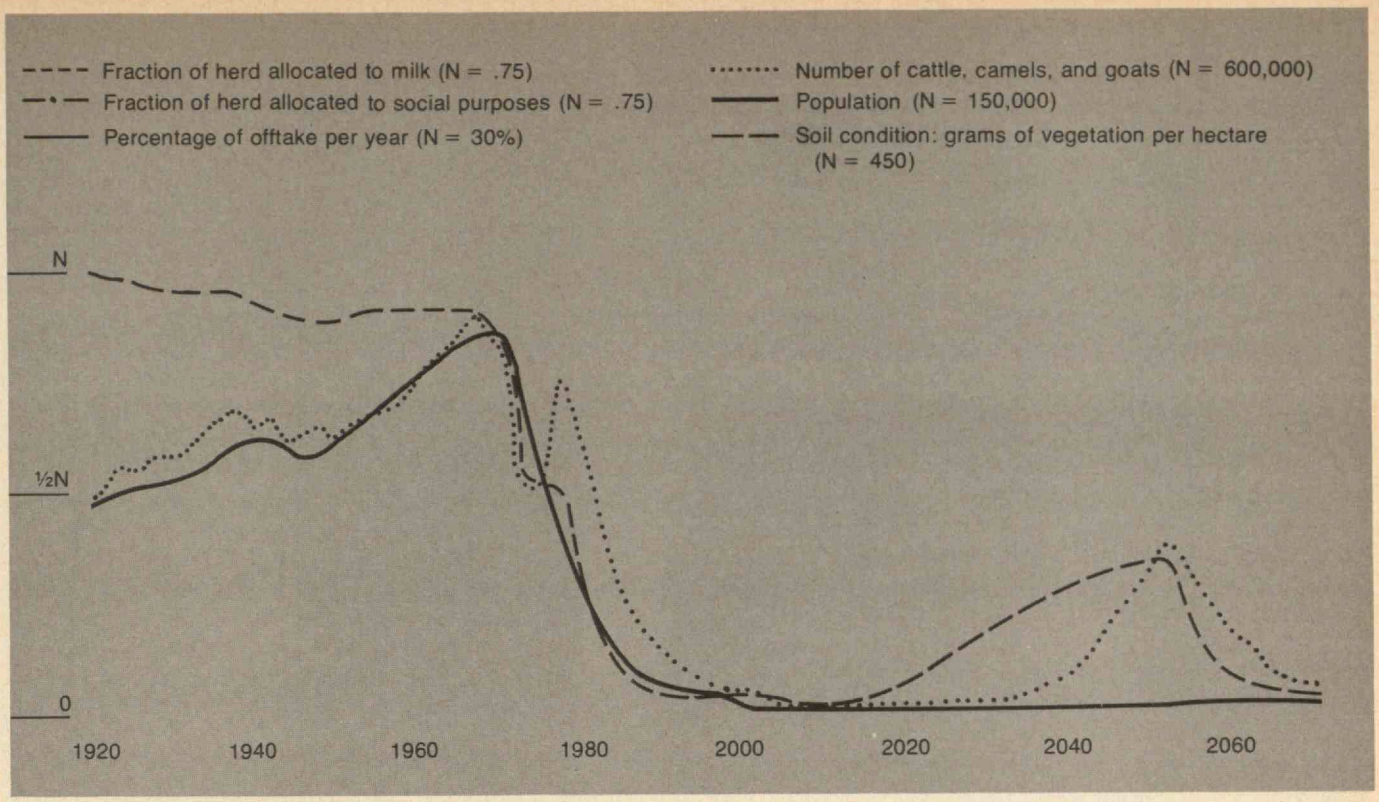
The farmers welcome having cattle graze on the millet stalks and other crop residues after the crops are harvested, because in the process the animals fertilize the fields. A symbiotic arrangement is thus established and the herdsmen have customary "clients" among the agriculturalists to whom they regularly return with their cattle. However, the herdsmen delay the southerly portion of their trek until after harvesting to avoid having their cattle wander into unharvested fields, thus incurring the farmers' wrath and possible heavy fines. Although herdsmen do not own particular pastures in the sahel, individuals traditionally return to the grazing lands and watering holes they have used in the past. They prefer this to crowding another family's pastures and incurring social debt, or going where they are unsure of the availability of water.

Thus a herdsman calculates his seasonal movements to avoid exposure to fines and debts, or herd loss to disease. In times of drought, herdsmen are reluctant to change their habits radically and continue to follow traditional migratory patterns. Customary pastures are severely overgrazed during the onset of a drought in the expectation that rains will return shortly, if not in the next few weeks, then in the following year. Most of the time this strategy is effective, because rainfall in any one area does show large year-to-year variations.

The herdsman thus minimizes the chance that he will lose his herd or be caught with an inadequate milk supply — both eventualities spelling hunger and possible death in the sahel. When pastures are poor because of overgrazing and/or inadequate rain, the individual's only insurance is to increase his herd. Herdsmen heavily discount the long-term effects of overgrazing. Pastures, while they have customary users, are in actuality common ground. Preservation of a given pasture would only encourage other herdsmen to take advantage of it. Thus, the conservation-minded herdsman who restricts his own herd size would not only pay the total cost of his good management but also be obliged to share the benefits — a classic example of a tragedy of the commons.

Intuitive Programs, Counterintuitive Results

In an effort to relieve the effects of the recent drought and the famine and herd losses which resulted from it, the heads of the francophone West African nations proposed a variety of technical assistance programs. They suggested that the various international aid organizations provide:
— veterinary services, in order to decrease the death rate of the stock;



Among the proposed technical assistance programs were the establishment of veterinary services, breeding programs, well-digging programs, reseeding programs, and restocking programs. If these were to be implemented, the above computer simulation indicates that they would result in the swift and total desertification of the range. The sahel could not tolerate such uncontrolled increases of the herds it supports.

— herd management and breeding programs for the herdsmen, an effort which would increase the number of breeders in each herd and the number of calves produced by each herd;
— well-digging and sanitary water supplies, which would increase the available pasture land and thus increase the population's expected lifetime from 40 to about 45 years;
— reforestation and reseeding programs, which would decrease the time required for recovery of rangeland vegetation; and
— restocking programs to increase the herds to their pre-drought levels.

With all good intentions, these programs essentially represent an intensification of past types of aid efforts in the sahel, and are based on the assumption that uncontrollable climatic aberrations are alone responsible for the tragedy.

We made models which simulate the effects of all these aid programs upon the sahel, and also simulate the effects of these programs in various combinations. The results of our simulations follow.

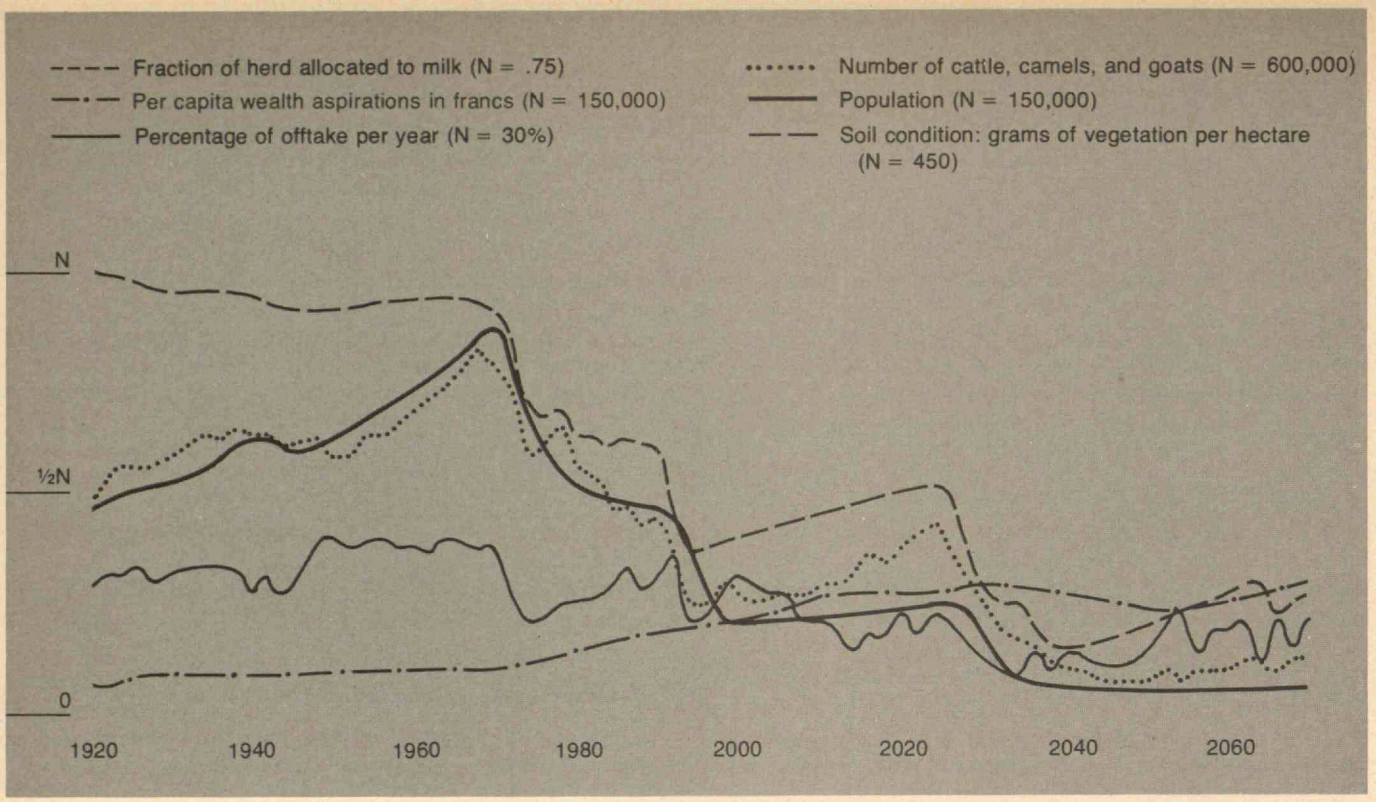
The Tragedy of Aid

As indicated in the figure above, our simulation model shows that these programs result in swift and total desertification of the range, as the animals are not removed from the range fast enough to preserve the ecosystem, in spite of the rather optimistic reseeding and reforestation program. The preceding discussion of pastoral dynamics, however, indicated that this behavior is to be expected, since, after a drought, herdsmen attempt to build up their herds as quickly as possible. Veterinary and restocking programs thus do not in themselves cause herdsmen to behave in a generically different manner, but merely allow them to satisfy their traditional priorities more quickly.

An increase in offtake rates would lessen the ecological pressures placed upon the grazing land and make the pastoral system more efficient from a meat production standpoint. The herdsmen now value their heads primarily for milk production and sell older animals only after they have become useless for milk suppliers or transport.

Herdsmen might be encouraged to market more of their stock, and their desire to obtain market goods might be stimulated, if the prices they receive for their animals were increased. Such a proposal has been made. Proposals have also been made to institute a variable tax on cattle based on the range conditions.

Those who propose such measures argue that increasing a herdsman's wealth aspirations and his ability to purchase goods initiates a self-reinforcing "revolution of rising expectations," which will cause the herdsmen to increase their offtake rates and thus decrease overgrazing. We simulated the effects of higher material aspirations in our model in raising the wealth aspirations of the herdsmen and raising the real 1970 cattle price.



Raising the price of cattle on the market would encourage herdsmen to sell more of their stock. Another economic incentive for destocking is the establishment of a variable tax on livestock, higher in times of drought. These proposals, if implemented, are shown in the above computer simulation. Under them, the range deteriorates. The failure of these programs in the long run rests on their inability to change the basic behavior patterns of the herdsmen. Their individual survival still depends on herd size.

Taxes now collected in the sahel are levied on a constant, per capita basis. We also used our model to simulate the effect of a tax rate which is held at a moderate level following years in which no serious overgrazing occurs but rises sharply as stock exceeds the carrying capacity of the range. (The new tax policy was simulated beginning in 1920 to show its effects during the two historical droughts.)

The results of these economic policies are shown in the figure above. A graduated tax policy increases the offtake slightly from 1920 to 1970, resulting in fewer animals on the range. Less overgrazing occurs and the range condition deteriorates more slowly during droughts than it does in the base run of the figure on page 46.

The model shows that per capita wealth increases as herdsmen aspire to and are able to purchase more goods, but the combination of these two policies does not cause the herdsmen to respond as hoped in a drought situation. Other simulations have shown that making the tax policy more severe only impoverishes the herdsmen (assuming it could be collected) and thus makes them more reluctant to offtake stock.

In summary, although higher simulated offtake rates resulted from this economic approach, behavior was not changed. The priorities of the herdsmen remain the same so that, when their own immediate survival is at stake, the range will be overgrazed.

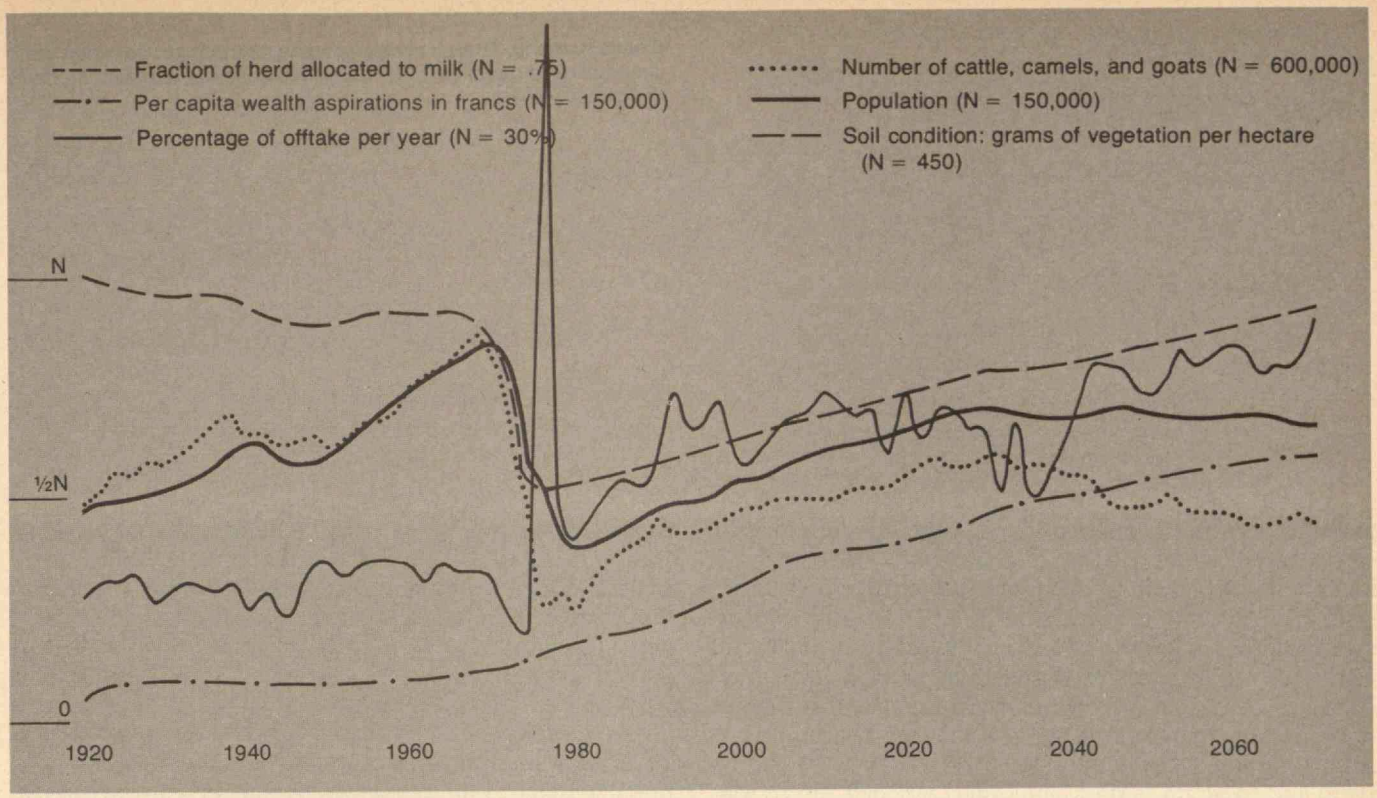
Combining Technical, Economic and Cultural Changes

The policies proposed and simulated so far have had no impact on the tragedy of the commons syndrome in the sahel. As long as each herdsman is primarily concerned with his own short-term survival, no combination of economic and technical programs will succeed in preventing the destruction of the range and the associated human suffering.

But, through our models we have found one successful, though unconventional, approach which achieves long-term viability in the sahel. The dynamics of the pastoral system resulting from this approach differ significantly from those of conventional approaches.

First, recall the basic rules of the sahel. To preserve the ecological resource base, the carrying capacity of the range should never be exceeded, regardless of rainfall. Overgrazing can be prevented by adjusting the stocking level each year to conform to allowable grazing levels through strictly controlled offtake rates or by importing enough supplemental feed so that animals won't overgraze the natural vegetation in years of rainfall shortage.

In our "successful" system, we postulate a change in cultural priorities, under which the herdsmen assign top priority to range conservation. This results in a fundamental change in the herdsmen's mode of operation. Even though such a change is highly unlikely, it is useful to show the extent of changes which must occur to result in a sustained improvement of the range. This policy was in-



The computer simulation shows the gradual recovery of the range, based on shifting cultural values to make range conservation, rather than preservation of the individual's herd, the central cultural priority. This simulation shows the result of immediate destocking of the range to a level at which overgrazing does not occur, and the introduction of a supplemental feed program in 1980. Other interventions are assumed to be similar to those in the two previous simulations. As cultural and technical change becomes more effective in protecting the herdsmen against famine, the social importance of livestock is assumed to diminish.

corporated in the pastoral simulation model starting in 1975 by requiring that the range be destocked immediately to the sustained yield carrying capacity (the maximum stocking level at which overgrazing does not occur). In 1980, a supplemental feed program is introduced that allows herdsmen to maintain their stock at the long-term average sustained yield level. Herdsmen market the livestock removed for conservation purposes and use the revenues to partially offset the cost of the supplemental feeding program.

Veterinary, herd management, and breeding programs are also introduced which are exactly the same as those simulated for the technological programs. The economic programs, including livestock price increases and wealth aspiration increases, are also included in this simulation. Finally, as this cultural and technical change becomes effective in protecting the herdsmen against future famines, the social importance of livestock is assumed to diminish greatly. This reduction, between 1980 and 2020, reflects the herdsmen's confidence in the effectiveness of their conservation efforts, and their relinquishment of maintaining excess animals as necessary insurance.

These changed cultural priorities, in addition to the technological, economic, and social changes, show a fundamentally different behavior mode than do the previous simulations *(see the figure above)*. Under this perfectly controlled grazing situation a slow but steady improvement of the soil condition takes place over a period of about 100 years.

This improvement is accompanied by a marked increase in offtake rates:

— The ecological system has a greater offtake potential because the range produces more forage each year as it recovers, and because the veterinary and herd management problems have eliminated a significant amount of wastage from stock production (although the herdsmen still consume milk, they are assumed to be more oriented toward beef production and marketing in this simulation than in the previous simulations);

— Herdsmen have a greater need to market animals due to their increased aspirations for market goods; the social importance of large herds is somewhat diminished, although not eliminated, so the stock which formerly served a social and insurance role can now be allocated to the remaining needs of the herdsman. Offtake rates finally level off at between 20 and 25 per cent, about twice their levels under traditional management. However, since range improvement causes the absolute number of animals eventually to increase by a factor of approximately two, the actual number of animals offtaken is much larger than under the traditional management practice.

Per capita wealth aspirations in the 40 years between 1970 and 2010 can be simulated by assuming an increased exposure of herdsmen to market goods such as radios, bicycles, porcelain cookware, new foods, printed cloth and a host of other imported consumer goods that

These nomadic Tuareg herdsmen may be forced to abandon their time-honored customs if the sahel is to continue to maintain them. (Photo: *NOVA*)

are presently permeating West African markets. After 2010, wealth aspirations continue to rise until around 2070 because the self-reinforcing goods acquisition/goods aspiration process has been fed by the pastoralists' general success in attaining wealth. The limited productive potential of the range halts population growth after 2030, because the resource base in the sahel can support no more people at their desired standard of living. As the indigenous population grows, offtake levels rise, and herdsmen are forced to allocate more of their stock to food production. Since they are unable to achieve further increases in per capita wealth, their future wealth aspirations will again be limited.

The population finally stabilizes because birth rates are in balance with death rates and out-migration rates. We based the effect on birth rates of more wealth and better health in the model upon data from a cross section of developing countries which is probably quite optimistic: future population levels will probably be higher than estimated. Death rates decrease with the elimination of famines and a generally higher nutritional status. The slight excess of births over deaths results in a continuing net out-migration from the pastoral region after 2030. Typically, in West Africa, when rural areas can no longer

support growing populations at the desired standards of living, the sons migrate to the cities. This chronic outmigration is becoming an increasing problem as former pastoralists migrate to cities, swell the labor forces, and crowd already overextended agricultural land in the sudan zone.

The Limits of Survival

We will not address the practical implementation of pervasive cultural change postulated here. There is good reason to doubt whether such a fundamental change can be brought about voluntarily, or whether it can be accomplished either voluntarily or by force before the range is destroyed. The central message of our computer simulation studies is that conventional programs and policies to increase production and relieve the effects of the drought are defeated by the tragedy of the commons syndrome.

Nor have we mentioned the ethical issues surrounding the aid proposals tested in this study, since our purpose here is only to examine the roots of the sahel tragedy and show the practical effects of some common approaches to aiding the pastoralists. There are many ethical issues. Is it advisable to continue traditional approaches to aid when these may have contributed to the problem? Do outside aid organizations from developed countries have the moral right to intervene in a fundamental and pervasive way in a traditional society? Can any such programs be implemented without excessive violence in the form of enforcement or corruption? Is the opportunity cost of scarce aid resources justified, considering it is allocated to the sahel while other candidates for aid, possibly with greater potential, are denied? (This is the question of triage.)

Human society is just beginning to grapple with the tragedy of the commons syndrome as it increasingly appears in even more crowded and congested situations in both the developed and developing world. At present the answers to none of the above questions are obvious and vary according to one's religious, moral, and political viewpoint.

But the fact remains that the pastoralists of the sahel can reverse the otherwise inevitable desertification of their land only by establishing the long-term preservation of the resource base as their first priority. The rather modest technical and economic programs we simulated are far beyond the economic means of the sahelian pastoralists. It is even doubtful whether the herdsmen can finance a supplemental feeding program by themselves. Far more important is the difficulty of incorporating range conservation concepts in the value structure of the herdsmen. Practically, one is asking the herdsmen to put a higher value on the long-term preservation of the ecosystem than on his own perceived immediate welfare. We who live in rich countries, with personal incomes 350 times greater than that of the sahel pastoralists', have not accomplished this. This is apparent from the manner in which the tragedy of the commons syndrome influences use of our fisheries, land, and a great many of our other commonly shared amenities. Is it realistic to expect the sahel herdsman, living so close to the limits of survival, to solve this fundamental social problem?

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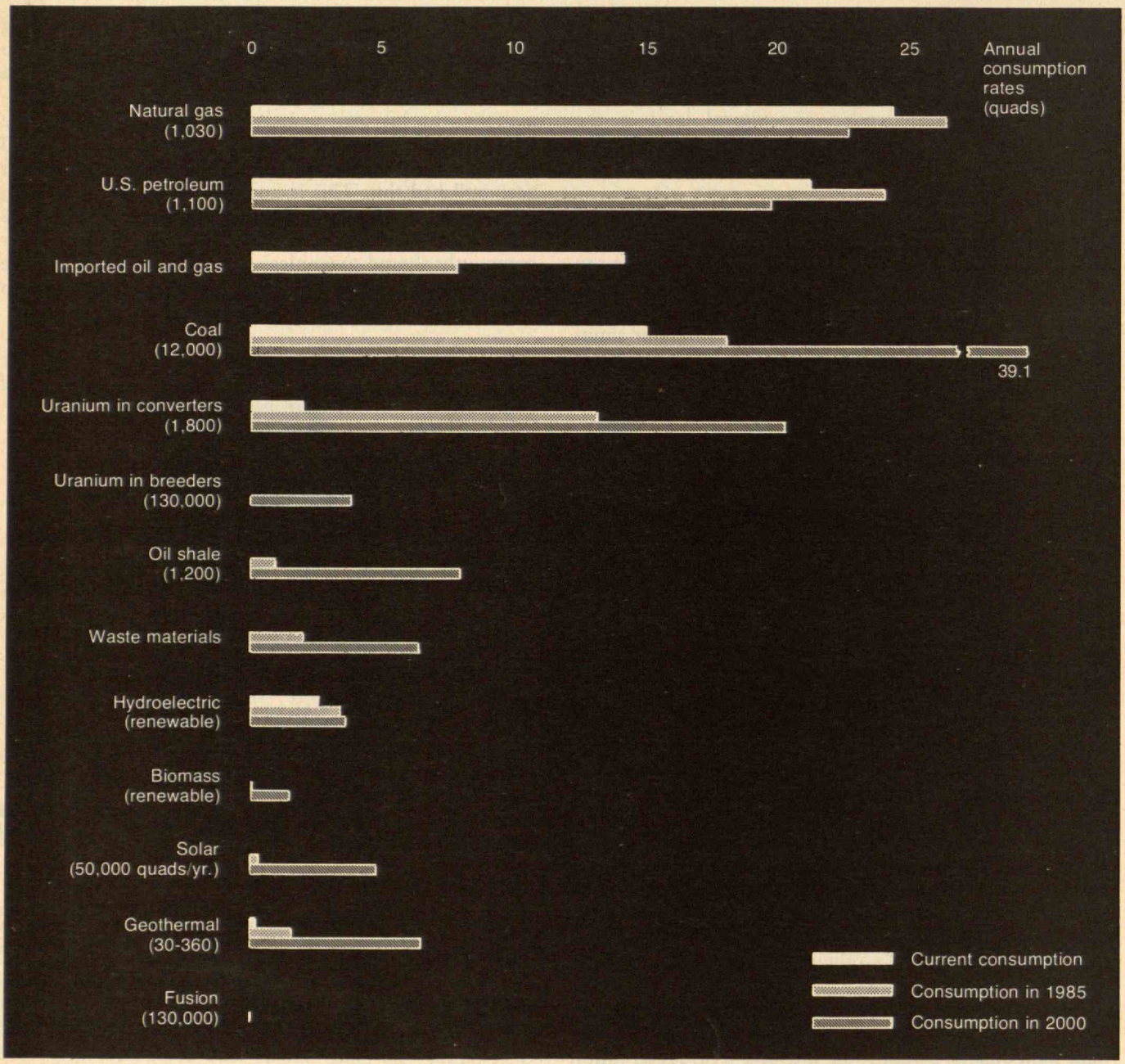
William W. Seifert, who received his S.M. and Sc.D. from M.I.T. in electrical engineering, is a professor of civil engineering at the Institute. He was the principal investigator for a U.S.A.I.D. study of West Africa from 1973 through 1975. His recent research has been directed towards developing dynamic models of social, political, and technical elements' roles in shaping the emerging nations.

No single energy resource will power the nation from now to the year 2000. Perhaps a mix of many will.



U.S. energy resources, and their consumption rates. Figures in parentheses are estimates of current supplies; the bars represent three consumption rates: the current rate (white) and E.R.D.A.'s predictions for the years 1985 (dotted) and 2000 (slashed). All figures are in units of *quads;* one quad is a million billion British thermal units. The figures for hydroelectric energy were calculated by assuming a 34 per cent efficiency in conversion of heat to electricity.

Manson Benedict
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M.I.T.

U.S. Energy: The Plan That Can Work

The recent increases in fuel prices have shown that low-cost energy is gone forever. The United States will have to shift from oil and natural gas to other, less convenient, and more costly energy sources. What options does the U.S. have to provide for its energy needs to the year 2000?

The Energy Research and Development Administration (E.R.D.A.) describes five alternative "scenarios" for meeting future energy needs. Only one of them, the fifth, seems to me both realistic and realizable; it calls for development and deployment of a balanced mix of numerous energy technologies, coupled with rational conservation. The other alternatives, which I shall not describe, emphasize single measures which, if adopted, would severely distort our energy economy without significantly reducing our dependence on imported oil.

The table on page 52 compares our present annual energy consumption with the energy consumption predicted in scenario five for 1985 and 2000, and with estimates of our energy resources. The unit of energy used for these comparisons is a million billion British thermal units, which is coming to be known as the quad. One quad of energy is produced by burning 40 to 50 million tons of coal, 180 million barrels of oil, or 1 trillion cubic feet of natural gas. Consumption of a million barrels of oil per day yields two quads of energy per year. To produce one quad of thermal energy in the type of nuclear power plant used in the United States today requires mining 2,000 tons of natural uranium concentrates.

An increase in annual energy consumption from 79 quads (the current figure) to 98 quads in 1985 and 137 quads in 2000 (the quantities predicted in scenario five) means a growth rate of 2.2 per cent per year. Our past energy growth has been around 3.5 per cent per year. The postulated reduction to 2.2 per cent is a plausible consequence of higher energy prices, lower population growth, and intensive measures to conserve energy. Zero energy growth, although desirable, probably cannot be attained in the next 25 years, given the projected increase in U.S. population and the need to use additional energy to compensate for the depletion of mineral resources.

Domestic and imported oil and gas now provide almost 75 per cent of present energy supplies. This fraction will have to be reduced drastically in the future.

Although conservation doesn't appear in the table, it has been assumed in keeping future energy consumption as low as stated. Necessary conservation measures in our private lives include more efficient automobiles and appliances, better insulated homes, and less waste. Industry and business must adopt more efficient processes, recover waste heat, and reduce energy consumption for heating and cooling buildings.

Natural Gas: Declining Rapidly

Natural gas is a dwindling resource: domestic production peaked at around 22 quads in 1972 and has been declining since. If a pipeline to deliver gas from Alaska is completed by 1985, production will increase temporarily to 24 quads. E.R.D.A.'s higher estimate of 26.5 quads by 1985 depends upon well-stimulation techniques which are not economic at today's low regulated prices, but which might be used if the price were deregulated.

Even with well stimulation and extensive offshore development, natural gas production promises to decline inexorably after 1985. Total resources are estimated at 775 quads without stimulation, and perhaps 1,030 with it. Since this is only a little over 40 years' supply at the present consumption rate, development of alternative energy sources and strict conservation are obviously essential.

Gas is a premium fuel for home heating and chemical feed stock. Its use for purposes for which other fuels suffice, such as generating electricity, is a luxury we can no longer afford. The shortfall in gas supplies after 1985 will have to be made up by synthetic gas, mostly from coal.

Petroleum: Alternatives Essential

The supply of U.S. petroleum is as critically short as the supply of gas. Domestic production declined by almost a million barrels per day last year, about two quads per year. Completion of the Alaska pipeline will temporarily increase production by 2 million barrels per day. Extensive offshore production (now restricted in many states) and use of advanced recovery and production techniques could increase U.S. petroleum production to 24 quads in 1985. Then, like natural gas resources, it will decline.

The figure on page 54 shows recent U.S. Geologic Survey estimates of our petroleum liquid resources, converted to quads at 5.5 quads per billion barrels. "Demonstrated reserves" of 215 quads are those whose location, amount, and production costs are known well enough to serve reliably for business planning. These reserves represent about eight years' supply at present production rates. "Inferred reserves" are those expected to be found in known formations geologically similar to those already demonstrated. "Undiscovered resources" have an estimated 50 per cent probability of discovery from future

U.S. petroleum resources, as estimated by the U.S. Geological Survey. Again, the figures are given in quads — a million billion B.t.u.s. Three categories are given, each more uncertain than the preceding: demonstrated reserves are sufficiently certain that business decisions can be made concerning their exploitation, while undiscovered resources have only a 50 per cent chance of being found. Inferred reserves are also undiscovered, but the geological formations are known to be favorable to their existence. The most uncertain "resources" make up more than half of the total U.S.G.S. estimate.

	Demonstrated reserves	Inferred reserves	Undiscovered reserves	Total
Onshore				
Lower 48 states	140	79	242	461
Alaska	55	34	66	155
Offshore				
Lower 48 states	19	14	61	94
Alaska	1	0	82	83
Total quads	215	127	451	793

exploration. Unfortunately, they constitute more than half the total resource estimate of 793 quads.

To the Geologic Survey's precarious forecasts, E.R.D.A. adds 300 quads potentially available through tertiary recovery methods, such as CO_2 injection or other techniques which may become economic as oil prices rise. The total resource estimate of 1,100 quads is to be compared with our present consumption rate of petroleum, domestic and imported — around 35 quads per year.

Since domestic supplies of petroleum are so limited, means to reduce consumption of liquid fuels and increase their synthesis from other sources must have the highest priority. Measures which must be taken to reduce consumption include increased use of electric propulsion for trains and short-haul automobiles and trucks, development and mandatory use of more efficient engines for automobiles and trucks, and the phasing out of oil for steam-electric power generation. Equally essential is the development of alternative sources of liquid fuels. In the year 2000 in scenario five, eight quads of shale oil are produced and 15.9 quads of coal are converted to 10.5 quads of oil. Through conservation and this production of 18.5 quads of synthetic oil from shale and coal, the amount of oil imported could be reduced to zero.

Oil Shale: Many Problems

The proposed use of oil shale presents major developmental, environmental, and financing problems. One ton of the richest U.S. oil shale produces only four-fifths of a barrel of shale oil, whereas one ton of crude oil produces six barrels of refined products. To produce eight quads of energy per year from oil shale, as scenario five stipulates, we must mine 1.8 billion tons of oil shale per year, three times the rate at which we now mine coal. For eight quads per year, the rate of oil shale production would be about 4 million barrels per day. Since an oil shale refinery will cost at least $15,000 per daily barrel, the investment in oil shale plants would come to over $60 billion. Fred Hartley, Chairman of the Union Oil Co. and a pioneer in shale oil development, says his company could construct 20 processing plants, each producing 7,000 barrels per day. But to reach 4 million barrels per day, 600 such plants would be needed, and 30 companies with Union's capabilities to build them.

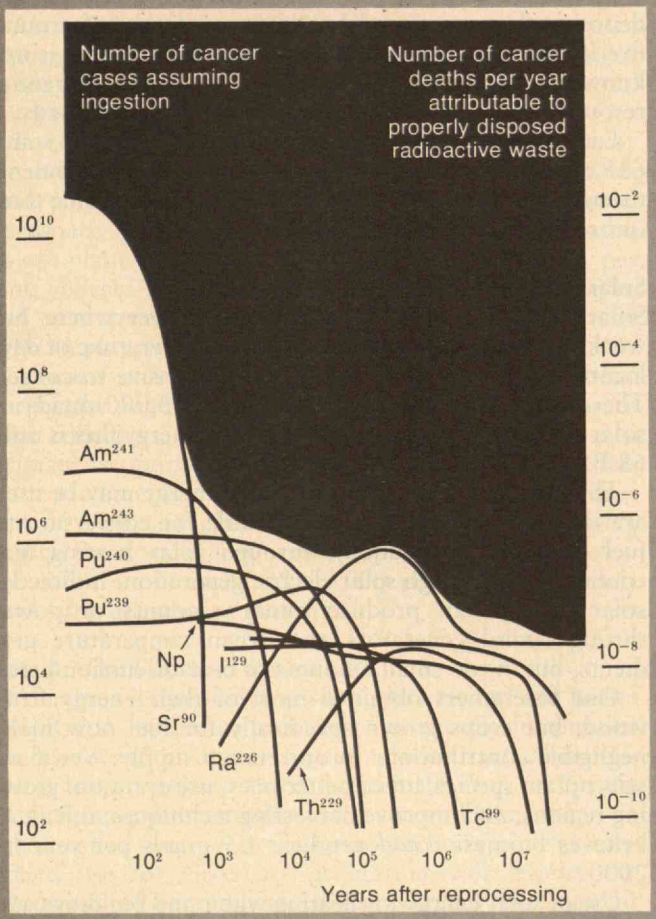
Economic feasibility isn't the only problem for oil shale production. Restoration of land scarred by mining 1.8 billion tons of shale per year, disposal of the nearly equal mass of refuse, elimination of carcinogens from shale oil and refuse, and provision of the large amounts of water needed for refineries are additional obstacles. Disposal of refuse by return to mine or quarry is often logistically infeasible, and in any case is not a complete solution since the refuse occupies greater volume than the oil shale from which it was made. The best technical solution appears to be the burning out of harmful residues in oil shale refuse, which could then be piled in dry canyons contoured as closely as possible to the neighboring terrain, followed by assistance of regrowth of natural vegetation.

Hydroelectric and Geothermal Energy: Geographically Restricted

Although hydro sources generate some of the cheapest electricity in the United States, they have little growing room. Almost all the economic sites have already been put to work or are in regions reserved for recreation or wildlife preservation. Moreover, hydrogeneration shares

The Lifesaving Powers of Nuclear Wastes

The potential for harm of long-lived nuclear wastes has in general been the subject of more emotional than rational analysis. To remedy that omission, Bernard L. Cohen of the University of Pittsburgh has now correlated the radioactive elements in the wastes of pressurized water reactors with the cancer-induction probabilities of various isotopes, as estimated by the National Academy of Sciences in its 1972 report on the effects of exposure to low levels of radiation. His conclusions appear in the January *Physics Today* (pp. 9-13).



High-level radioactive wastes are an unwanted by-product of nuclear fuel reprocessing, but perhaps not all that dangerous. Bernard L. Cohen has modeled the increasing incidence of cancer attributable to wastes generated by a U.S. nuclear power industry in supplying 400 million kilowatt years of electricity, substantially more than today's total annual electric energy consumption. At the left are the total numbers of cancer cases induced by complete human ingestion of all the waste — an impossible scenario. Those at the right show the deaths resulting when the same amounts of wastes are buried 600 meters deep. (Chart: *Physics Today*)

His calculations on the basis of two alternative assumptions:

— All waste products resulting from the generation of 400 million kilowatt years of electricity, almost twice the present annual demand in the U.S., are ingested by the U.S. population — a scenario which is essentially impossible.

— All wastes from a similar amount of nuclear power generation are buried underground at random locations at a depth of 600 meters.

After 500 years, when nearly 100 per cent of strontium-90, the most serious hazard in fuel waste, would have decayed away, ingestion of all existing waste — the impossible scenario — would result in 10 million deaths. If all the existing waste were dissolved in public water supplies (of which one part in 200 is ingested) — again an impossible scenario — the cancer death toll would be 50,000.

If the same reprocessing waste were buried in long-term storage at a depth of 600 meters, it is fair to assume that the probability that an atom of such waste could reach and irradiate people by ingestion is no more than that for an average atom of radium in the rock or soil above it. In such a case, Professor Cohen's estimate is 10^{-6} deaths per year after 500 years. The details of his model are conservative, and he is confident that this is "an upper-limit estimate of deaths caused."

Professor Cohen cannot resist an additional observation: As uranium is mined and consumed in reactor fuel, the deaths due to natural uranium will decrease; and since the waste products of fuel are less dangerous after a few thousand years by Professor Cohen's estimate than the uranium consumed in producing them, future reactor development may save — rather than cost — human life.

"As our distant progeny look back on the late 20th century," concludes Professor Cohen, "they will never notice the tiny amount (one part in 10^{10} in our model for each year of all-nuclear power) by which we will have increased the radioactivity in their environment. We will rather be remembered as the ones who consumed all the high-grade mineral ores — all of the copper, nickel, zinc, tin, lead, mercury, and so on — and, worse than that, literally burned up at a rate of millions of tons per day those once-plentiful hydrocarbons — coal, oil, and gas — that are valuable as feedstocks for producing petrochemicals." — *J.M.*

	Equivalent thermal energy (quads)
Dry steam	4.3
High-temperature (>150°C) water:	
Producible at competitive prices	31.4
Known fields, producible at twice competitive prices	71.9
Possibly discoverable and producible at twice competitive prices	205
Intermediate-temperature (90-150°C) water	82.3
Geopressured hot water	80.8 to 314

U.S. geothermal energy resources, according to the U.S. Geological Survey. The resources take three forms. Only one *dry steam* field exists. Of *hot water* resources, those at 150°C. or less cannot be used for generation of electricity, but could be useful for space heating. Finally, a *geopressured hot water* supply exists on the north shore of the Gulf of Mexico, at depths for which the production cost is unknown.

the disadvantage with geothermal energy of being geographically restricted. In 1973, U.S. hydrogeneration amounted to 273 billion kilowatt-hours, or 2.7 quads expressed as equivalent thermal energy by using a generation efficiency of 34 per cent.

U.S. geothermal resources take three forms: dry steam, hot water, and geopressured hot water. Their magnitude is shown in the table above. Our only dry steam field, at the geysers in Northern California, will produce 1,200 megawatts of electricity for Pacific Gas and Electric Co., at competitive prices. The total electric potential of this field is estimated by the U.S. Geologic Survey to be 477 megawatt-centuries, or around four quads equivalent thermal energy.

Numerous fields of high-temperature hydrothermal water in the western states could be used for electric generation, probably at competitive prices; they could yield over 30 quads. Hot water is more difficult to use than dry steam because more fluid has to be produced and the content of dissolved corrosive material is much higher. Nevertheless, San Diego Gas and Electric Co. is planning an experimental generating station, and it seems reasonable to count on this resource for significant amounts of electricity in the western U.S. The U.S. Geologic Survey estimates that a total 200 quads of hot water, yielding electricity at up to twice today's price, may be found. In addition, numerous sources of lower temperature water, totaling 82 quads, might be used locally for space heating, replacing fossil fuels.

The north slope of the Gulf of Mexico has extensive deposits of geopressured hot water at depths of around five kilometers. Production cost from these depths is unknown, and possible land settling is a concern. Potential resources are estimated at between 80 and 300 quads.

Estimates of total useful resources lie between 35 and 615 quads. Geothermal energy is worthy of development, though limited geographically and of less magnitude than our remaining oil and gas.

Solar Energy: Necessary and Possible

Solar energy is a paradox. It is available everywhere, but weak. It is enduring, but varies with weather, time of day, location, and season. It is free, but expensive to collect. The continental United States receives 50,000 quads of solar energy each year, but the average energy flux is only 68 B.t.u.s per square foot per hour.

The principal ways in which solar energy may be used are through growth of crops suitable for conversion to fuel (biomass production), through solar heating and cooling, and through solar electric generation. Indirectly, solar energy can produce minor amounts of power through wind generators and ocean temperature gradients, but in too small amounts to bear discussion here.

Our forefathers obtained most of their energy from wood, but crops grown specifically for fuel now make negligible contributions to our energy supply. Yet if we select plant species, breed better ones, use optimum growing regions, and improve harvesting techniques, E.R.D.A. believes biomass *could* produce 1.5 quads per year by 2000.

Use of solar energy for heating water and buildings and for low-temperature industrial processes is feasible, and at today's high fuel prices, these uses should grow rapidly, especially in new structures specifically designed for them. In much of the United States, each square foot of solar collector could collect 150,000 B.t.u.s per heating season, thus saving 1.5 gallons of fuel oil burned at 70 per cent efficiency. With fuel oil at 40 cents per gallon, and a capital charge rate of 15 per cent per year, this fuel saving justifies investment of $4 per square foot for solar collec-

tor and associated pump, piping, and heat storage. Installed costs today are around $15 per square foot, and the total cost for a typical house is around $3,000. Nevertheless, improved technology, mass production, increased fuel prices, and government subsidies to encourage fuel conservation should lead to extensive use of solar heating. As it isn't economic to provide all heat needed during coldest weather, perhaps 70 per cent of a building's annual fuel could be saved by solar heating.

About 18 per cent of U.S. energy is devoted to space heating. If 25 per cent of U.S. buildings adopted solar heating by 2000, we could save 3 per cent of our total energy reserves — perhaps four quads per year.

Two methods for converting solar energy to electricity are being developed, thermal and photoelectric. Both have a long way to go before they can be economic. Aerospace Corp. has estimated that a thermal solar power plant could have an overall efficiency of 13 per cent, collect 72 per cent of the sunlight incident upon it, and have a unit capital cost of $2,385 per kilowatt in 1990. A plant meeting these criteria and generating 1,000 megawatts of electricity during sunlit hours (and none during the night) would require eight square miles of solar collectors. M.I.T.'s Hoyt C. Hottel thinks the cost estimate is optimistic. Even so, the cost, assuming this plant produces electricity ten hours per day, is 2.5 times that of a nuclear plant of the same capacity operating around the clock. The unit cost of photovoltaic solar electric collectors is around $100,000 per kilowatt, clearly out of the question at present.

	Light-water nuclear	Low-sulfur western coal	High-sulfur eastern coal
Unit capital cost ($/kw.)	863	565	697
Fuel cost ($/million B.t.u.s)	0.60	3.24	3.04
Cost of electricity (cents/kw.hr.)			
Capital	2.690	1.798	2.374
Operation and maintenance	.307	.264	.425
Fuel	.625	2.902	2.880
Total	3.622	4.964	5.679

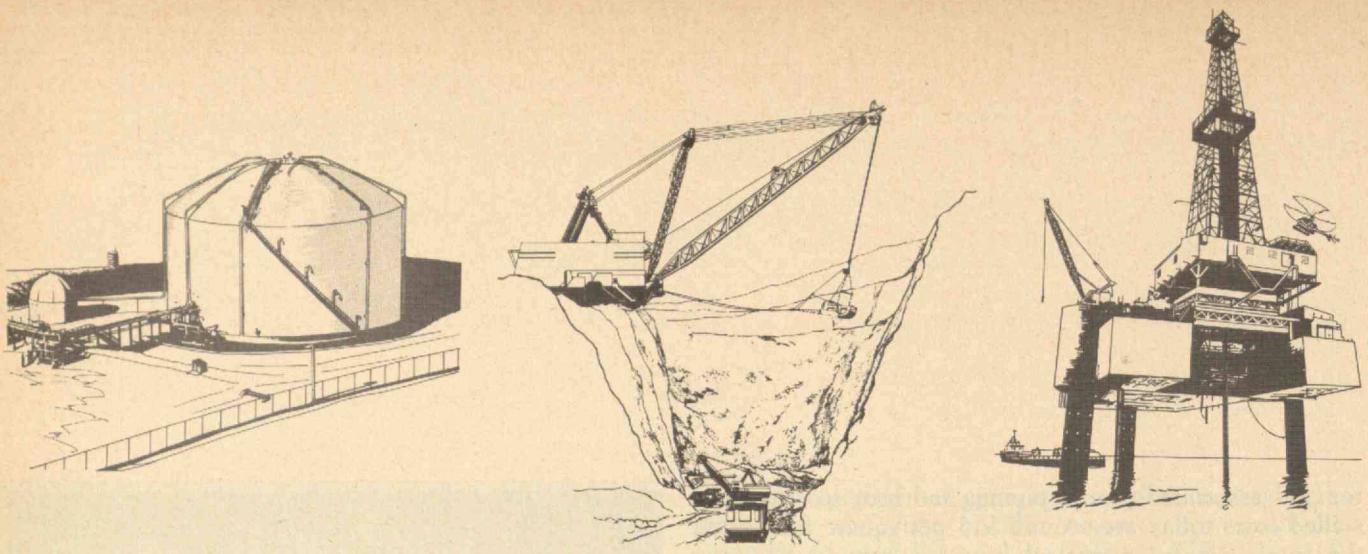
The projected cost of electricity in New England, 1985 to 2000. Three types of generating plant are considered: a light-water nuclear fission plant, a coal-fired plant using low-sulfur western coal, and a similar plant using high-sulfur eastern coal. The figures are taken from a report by Arthur D. Little, Inc. and S. M. Stoller Corp., to New England Electric Co.

Fusion: The Ultimate Source

Of the three technologies — solar, the breeder, and fusion — E.R.D.A. names as providing "essentially inexhaustible resources," fusion is the one whose practical utilization is least certain to succeed and furthest in the future. Fusion energy is here today in the sun and stars and — in uncontrolled form — in the hydrogen bomb, but its controlled use for electricity generation will require development of very advanced technologies that are far from certain to be practical.

The fusion reaction that proceeds at the lowest temperature is between deuterium, the heavy isotope making up one part in seven thousand of natural hydrogen, and tritium, a radioactive isotope of hydrogen produced from lithium. The temperature needed for this reaction is merely 100,000,000°C. Two schemes under development for achieving this enormous temperature in controlled fashion are magnetic confinement of hot ionized hydrogen gas, and implosion of hydrogen capsules by focused laser beams in a fusion internal-combustion engine. Neither scheme has yet reached the breakeven point, where the amount of fusion energy produced equals the amount of energy consumed to produce the reaction. Both schemes have stubborn materials problems because of high temperatures and intense radiation.

Surely, fusion cannot contribute to U.S. energy production till the next century at the earliest. But if successful, a 1,000 megawatt fusion power plant would be fueled by only four metric tons of lithium and the deuterium in 2,640 tons of water per year. Of these two, lithium is the less abundant resource. In 1970, the U.S. Geological Survey estimated U.S. known and inferred lithium reserves at 6 million metric tons, equivalent to 1.5 million megawatt centuries of electric energy or 130,000 quads of thermal energy. If we could extract lithium from the ocean, the 250 billion tons there would provide the world with 600



billion megawatt centuries of electricity, or 5.5 billion quads of thermal energy. This enormous extension of energy resources is what makes fusion research so important, despite its great difficulty and uncertain success.

Coal: A Versatile Fuel

We have seen that domestic supplies of gas and oil are giving out and that new energy sources such as oil shale, solar energy, and fusion will not replace them in this century. The deficiency will have to be made up by coal and uranium. Of these, coal is the more versatile. It can be converted to substitutes for petroleum and natural gas, and it can produce heat and electricity. Uranium is good only for the latter.

Scenario five predicts that in the year 2000, 5.3 quads of coal will be converted to gaseous fuels, 15.9 quads to liquid; and 8.4 quads will fuel 219 gigawatts of electric generation. An additional 9.5 quads will be used for heating and metallurgical purposes.

These statistics don't suggest the difficulty of achieving these goals. We will have to mine over 1.8 billion tons of coal per year, almost three times the present rate. And this increase must take place despite increasing concern about the hazards of underground coal mining and the scarring of land in strip mining. Processes, mostly German-developed, exist to convert coal to synthetic natural gas, but they are expensive and inefficient, losing one-third of the coal's energy in conversion. Synthetic gas is likely to cost over $2 per million B.t.u.s — ten times what regulated natural gas recently sold for at the well.

Processes for converting coal to liquid fuels are less well developed and will require extensive pilot plant demonstration before commercialization. Yet the critical need to reduce our dependence on foreign oil gives this development highest priority. Scenario five's proposed capacity to convert 16 quads per year of coal energy to liquid fuel by 2000 will require facilities costing on the order of $100 billion.

Even the conventional use of coal for electric power generation has its difficulties. Sulfur oxides and small ash particles in stack gases are health hazards. E.P.A.'s prohibition on burning high-sulfur coal has temporarily impounded most eastern coal — 35 per cent of our coal resources. Systems to remove sulfur oxides from power plant stack gases are expensive; they break down frequently and produce large amounts of solid wastes. They are not considered a satisfactory long-term solution.

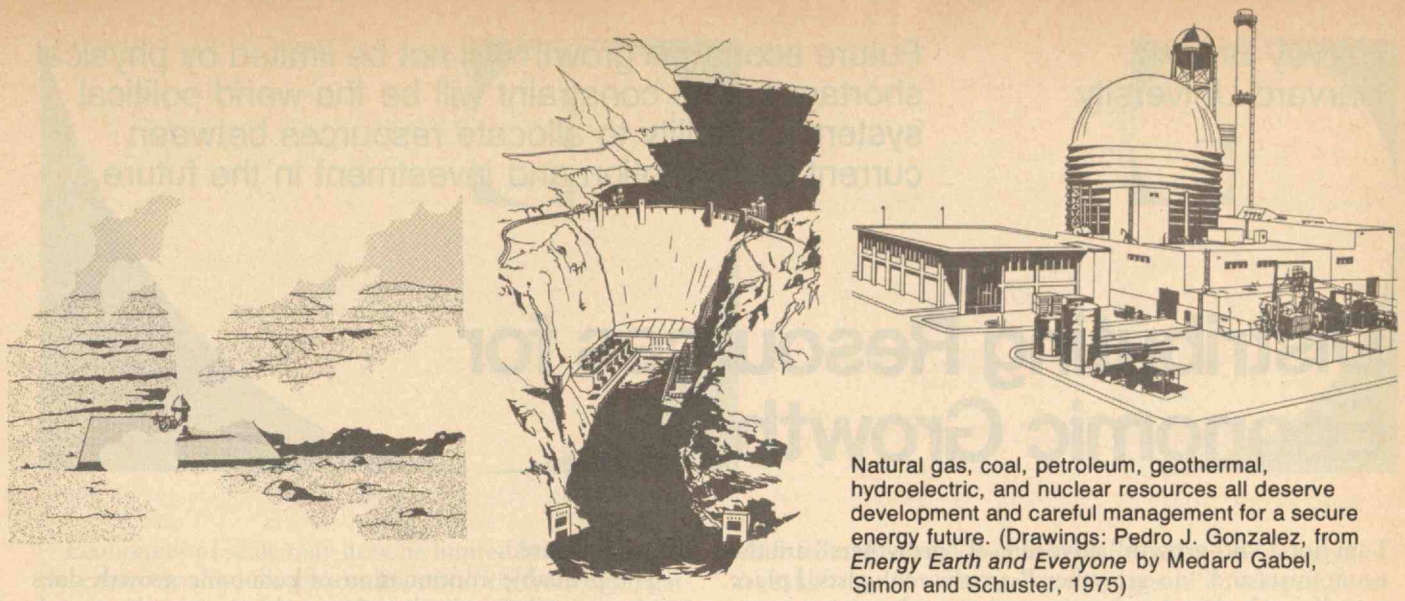
A better method proposed for future coal-burning plants is to convert the coal to low B.t.u. gas in which sulfur is present as hydrogen sulfide, then remove the hydrogen sulfide, and burn the clean gas under boilers. Compared with scrubbing sulfur oxides from stack gases, the advantages are the smaller volume of gas to be treated and the feasibility of converting hydrogen sulfide to elemental sulfur, a readily stored end product. Another alternative for making a low-sulfur boiler fuel from coal is solvent refining. All these means for converting coal to electricity will probably be demonstrated successfully, but they reduce conversion efficiency and increase electricity costs.

Nuclear Energy: Risks and Rewards

Since coal is our best alternative to vanishing reserves of petroleum and natural gas, we shouldn't waste it on electric power generation. Fortunately, electricity can now be generated at lower cost from uranium than from coal in most of the U.S. A recent study by Arthur D. Little, Inc. and S. M. Stoller Corp. for the New England Electric System forecasts that in the period 1985 to 2000, the cost of electricity in New England will be 3.6 cents per kilowatt-hour from light water nuclear power plants, 5.0 cents from plants burning low-sulfur western coal and 5.7 cents from high-sulfur eastern coal, with stack-gas scrubbing. The table on page 57 summarizes these forecasts. The cost of fuel in a nuclear plant is only one-fifth that in a coal plant; this fuel cost saving more than offsets the higher capital cost of the nuclear plant.

Because they produce electricity at lower cost, numerous nuclear plants are being added to U.S. generating systems. Their present capacity is 40,000 megawatts; the total capacity of plants now ordered is 210,000 megawatts. E.R.D.A.'s scenario five postulates a nuclear capacity of 450,000 megawatts by 2000 at a cost of $388 billion — $863 per kilowatt. To generate the same amount of electricity from oil, we would have to burn 11 million barrels per day, which equals the present total U.S. oil production rate. To generate the same amount from coal, we would have to burn about a billion tons per year, almost twice the present rate.

All U.S. nuclear electricity is now produced in water-



Natural gas, coal, petroleum, geothermal, hydroelectric, and nuclear resources all deserve development and careful management for a secure energy future. (Drawings: Pedro J. Gonzalez, from *Energy Earth and Everyone* by Medard Gabel, Simon and Schuster, 1975)

cooled reactors, which consume about 150 tons of natural uranium concentrates per year per 1,000 megawatt plant. Hence 450,000 megawatts would consume 67,500 tons of uranium concentrates. At that rate, our 3.5 million tons of estimated reserves will last about 50 years, a bit longer than oil and gas.

But this isn't the whole picture. Water-cooled reactors convert to heat only about one per cent of uranium's energy content. The process depends upon fission of the scarce isotope uranium-235 which makes up 0.7 per cent of uranium, and conversion of a small fraction of the abundant isotope uranium-238 to plutonium, which then undergoes fission. But in the liquid metal fast breeder reactor, cooled by sodium, almost all the uranium-238 is converted to plutonium, so that around 70 times more energy can be obtained. U.S. uranium resources, 1,800 quads without the breeder, are thus increased to 130,000 quads with it.

The breeder also makes possible utilization of additional uranium in ores too lean to be economic for water-cooled reactors. The amount of such low-grade uranium is uncertain, but it must be large, so the breeder makes our uranium resource base much greater than 3.5 million tons (130,000 quads).

Obviously, the breeder is essential to our energy future. A 250 megawatt breeder has been operating successfully in France for over a year; a 350 megawatt breeder is planned for operation in the U.S. by 1983. In scenario five, E.R.D.A. assumes that 18 per cent of U.S. nuclear electricity will be generated by breeders in 2000, with the proportion increasing thereafter.

What of the potential risks of nuclear power systems? I believe they can be dealt with so satisfactorily that the incidence of disease or death will be much lower than that from operation of coal-fired power plants of the same capacity.

Routine emission of radioactivity from nuclear plants is being controlled so that radiation exposure offsite is only a few per cent of the natural radiation background. Accidental release of radioactivity through loss of reactor coolant or excessive nuclear reactivity can be made so low by redundant and diverse cooling and control systems that the probability of serious public exposure would be less than one per million years of reactor operation. This is a conclusion of a study recently completed by M.I.T.'s Norman Rasmussen for the Nuclear Regulatory Commission.

Although plutonium is one of the most toxic substances known to man, strict measures that confine plutonium in nuclear facilities are preventing public exposure. How likely is plutonium theft? The only places in a nuclear power system where plutonium is pure enough and free enough of radioactivity to make theft a serious risk are plants that reprocess fuel discharged from reactors, and plants that fabricate fuel for reactors. By locating both types of plants on the same site and providing adequate guards and inspectors, risk of plutonium diversion can be made acceptably small.

Nuclear reactors discharge long-lived radioactive wastes. Although they must be kept out of contact with humans for thousands of years, this can be done safely by storage in salt deposits or other deep geologic strata demonstrably remote from ground waters. The volume of wastes is not large. One 1,000 megawatt power plant produces only 80 cubic feet of highly radioactive waste per year.

The unparalleled safety record of nuclear plants is best attested by the fact that, until now, no member of the public has even been injured, much less killed, by nuclear-related accidents or materials. No other new and potentially hazardous industry has this perfect record.

To sum up: rapid depletion of U.S. oil and gas reserves requires development and use of a number of alternative energy resources. But no one resource can do the whole job; a balanced mix of many is required. Of alternatives to oil and gas, our greatest reliance — at least for the next generation — must be placed on coal and uranium. Coal is indispensable for producing gaseous and liquid fuels, and for some electric power generation. Uranium is essential as the mainstay of our electric power industry. Scarcity and high cost demand conservation and efficient energy use in industry and our private lives.

Manson Benedict is Institute Professor, Emeritus, at M.I.T., where he was the first Head of the Department of Nuclear Engineering. He is a distinguished leader in U.S. nuclear engineering: past Chairman of the General Advisory Committee of the Atomic Energy Commission, former member of the A.E.C.'s Advisory Committee on Reactor Safeguards, and recipient of the Enrico Fermi Award (1972) of the U.S. Atomic Energy Commission. This April, he was awarded the Founders Award of the National Academy of Engineering "for his outstanding engineering accomplishments."

Harvey Brooks
Harvard University

Future economic growth will not be limited by physical shortages. The constraint will be the world political system's inability to allocate resources between current consumption and investment in the future.

Distributing Resources for Economic Growth

I am not a "no-growth" advocate. If "growthers" are the economists and "no-growthers" are the ecologists, I place myself much closer to the economists, with some reservations.

To me the real difference between these extremes is their time perspectives. Many economists discussing the relative merits of economic growth stop at the end of the 20th century; most ecologists are thinking well into the 21st century. Yet, in the public's mind there is often much confusion between immediate crises and long-term problems.

In my opinion no physical or technical shortage of any resource required for economic growth is likely in the foreseeable future, given the necessary degree of sociopolitical foresight and the social will to act on it. Our problems today and certainly for the next two generations do not lie in the physical capacity of the natural world to meet human needs. They lie somewhere else.

Economic Growth as Creative Destruction

I make two assumptions. First, some leveling off of population growth is inevitable within the next half century, due either to declining birth rates, or to greatly increased death rates in the underdeveloped world's vulnerable one- to four-year-old age group. This age group is the most vulnerable to inadequate food and nutrition. There may be a fortunate, cold-blooded irony in the fact a more unbalanced food/population equation will act differentially on this youngest group of the population. The young may never be added permanently to the population: therefore, the vision of a huge and starving adult population may prove unrealistic.

My second assumption stretches the imagination a bit more. It is well articulated by Hans Landsberg in his 1964 report, "Resources for the Future": the assumption ". . . that scientific and technologic advance will have to be continued unabated and the results will have to be translated into economic reality, and that we will continue to extend a world trading and investing system in which raw materials deficits can be met through imports from countries with a surplus of these materials." In other words, economics will prevail over politics, efficiency will prevail over equity. This last is a paradox to which I will return.

The hope that these assumptions will be fulfilled in the future seems considerably dimmer than it was when Landsberg wrote those words. It assumes that disaster — and there is a high probability of disaster — will not come because of the physical limits of our planet. The cause will be humanity's incapacity to organize to provide for its own future.

The probable continuation of economic growth does not necessarily imply that the world can get along with business as usual, or that current trends in tangible consumption can continue. Economic growth has in fact never rested on the continuation of current consumption trends. Technologies have come and gone. The street railway was the great wave of the future around the turn of the century; the automobile was the wave of the future until the 1960s; and the airplane has been heralded since the beginning of the 1960s. As Schumpeter has phrased it, economic growth is a process of creative destruction, in which a series of different technologies emerge and gradually disappear. The one certainty of economic growth is that the future will be different than the past.

The Value of Sacrifice

Continued economic growth at anything like past rates will require a greater proportion of investment. Consumption will have to be deferred if more consumption is to become possible.

We are even now in a crisis with respect to the real rate of saving. At this moment, corporations are probably losing money, considering the true replacement value — with depreciation — of plants and equipment, and inflation.

In addition, the investment per unit required to extract each unit of new resources will almost certainly increase for two reasons. First, the resources come from less and less concentrated ores, so that the amount of material to be handled per unit of useful product is constantly increasing. Second, the cost of resource extraction or recovery from wastes is intimately related to the cost of energy. Indeed, extraction and processing of resources by the materials industry as a whole probably uses 65 per cent of *all* the energy consumed by the industrial sector in the U.S. With industry using just over 40 per cent of all energy, about a quarter of all energy used is therefore associated with extraction and conversion of mineral resources.

In addition, I suspect that the materials and power industries may be nearing the realistic limits of economies of scale. In the last century, coal mining, oil extraction, oil refining, and electric utility generation all benefited from enormous economies of scale, and the unit cost of resources diminished at a rate between 10 per cent and 25 per cent for each doubling of cumulative production (11 per cent for oil refining and 25 per cent for electric power generation, to be precise).

Economies of scale may now be limited largely because the environmental diseconomies, resulting from aggregating production in one place, outweigh the overhead economies from very large plants. The upward surge in the capital cost of power plants, particularly nuclear power plants, is just one symptom of such a diseconomy of scale.

The Value of Labor

Economic growth in the past century was characterized by rising costs of labor relative to resources and energy. The next century will see a long-term shift from high costs of labor to high costs of resources. Wherever it has been possible to substitute resources, especially energy, for labor, we have done so. Thus it took about 3.5 less manhours and an enormously increased amount of energy to produce a ton of almost any mineral in 1975 compared to 1921. This trend will probably continue, at a diminished rate, for several reasons: materials are getting harder to find, requiring more sophisticated exploration and the processing of more ore for a given amount of material; and a new era of rapid growth of the labor force is beginning. This second factor is a recent phenomenon.

During the decade between 1960 and 1970 the U.S. population, ages 16 to 24, increased by 54 per cent — a much larger increase than the population as a whole. That group is now moving into the work force. Hence, during the next decade, the rate of increase in the U.S. work force, even discounting the changing status of women and minorities, will accelerate greatly. This will certainly pull the cost of materials upward, because of the capital needed to employ that work force, and may also push the cost of labor downward. With nonunionized workers, that downward cost pressure is already apparent. The average starting salary of an industrial scientist has declined by 28 per cent in the last four years, and the average salary of a college professor has declined about 15 per cent in the last five years. For the first time in recent years real disposable income of labor has been moving downward.

The labor force is increasing at an even more unprecedented rate in the underdeveloped world. The rate of growth of G.N.P. would have to be 12 to 13 per cent per year in order to fully absorb the increased labor force in many less developed countries. Such rapid growth rates, with the savings or capital transfers necessary to sustain them, have been approached only in a few less developed countries, such as Taiwan, Malaysia, and South Korea.

The most polluting kinds of production are likely to shift from the developed to the underdeveloped countries, a result of environmental restrictions in developed countries and surplus labor supply in undeveloped countries.

Cheap labor could, of course, migrate from the underdeveloped countries into the developed countries. While this migration did occur in Europe over the last 20 years, it is slowing. Switzerland, the Scandinavian countries, and West Germany are now rethinking their labor policies, and any such future migration of labor from the less developed countries of the Mediterranean Basin is doubtful. So the alternative seems to be the migration of capital to the underdeveloped countries, to take advantage of surplus labor. In fact, that may prove to be an almost necessary condition for the continuation of economic growth in the developed part of the world.

The Political Problems of Economic Rationality

But can economic rationality prevail over political perceptions and aspirations in the allocation of resources? The conflict between the ownership and the political control of resources, which increases with the political self-consciousness of the resource-possessing nations, makes me pessimistic.

The industrialized countries are the chief source of the capital needed to develop the resources controlled by the less developed countries. Yet obtaining the capital and technological skills needed to develop these resources seems to require a transfer of economic ownership which engenders political problems. Moreover, the shift of manufacturing to take advantage of the labor supply in less developed countries depresses the labor market in the industrial countries, and thus generates political resistance.

Resistance to the geographical sharing of natural resources, already manifested by the O.P.E.C. cartel, has its counterpart even between regions within countries. The West seems less and less disposed to see its huge coal resources exploited too rapidly only to benefit the energy demands of the Northeast and the Midwest, especially when the East resists exploitation of petroleum deposits on its continental shelf. We seem to be returning to a sort of "Articles of Confederation" mentality, in which regions are less and less willing to see their resources exploited for the benefit of other regions, at least on the terms to which we have long become accustomed.

So, while resources are not scarce on a worldwide basis, they are scarce on a local basis. The world increasingly depends on the interchange and transfer of material resources. The places where resources are consumed are

more widely separated from the places where they are produced. Historically, many great civilizations were built on local resources. The flowering of Athens was based on the silver mines of Laurium. Britain based its industrial revolution on indigenous resources of coal, copper, lead, and iron: mid-19th century Great Britain produced 45 per cent of all the copper in the world. The power of the U.S., based on its own resource riches until much more recently, is in fact just beginning to move out of this position. That pattern of power from local resources has disappeared permanently. Now abundance of resources can be viewed only from a global, rather than a national perspective.

Or can it? Are we in the midst of a shift of political power to the large countries which still possess relatively abundant resources?

The Delicate Balance of Economics and Politics

Economic control is transferred only slowly; political control can change overnight, as in the dramatic case of the oil embargo. Political manipulation or control of supply such as exhibited by O.P.E.C. will increase. However, through its sheer quantity, oil is a unique commodity in some respects: the amount of oil we consume in a year is comparable to the weight of all solid waste our economy produces, and about the same in weight as all construction materials used. Fuels are therefore unique, because, for example, the amount of steel — by far the most abundantly used metal —is only about a twentieth the amount of fuel used in a year. Nothing else approaches fuel within a factor of a hundred.

The economist often builds models as though supply and demand changed slowly — so slowly that they can come to equilibrium before either can change by a large fraction. But when the price of oil increased by a factor of four overnight, the adiabatic approximation was not a useful approach. As the rate of resource consumption increases, supply and demand change more rapidly relative to the equilibration time. More and more the approach must be dynamic.

One must also examine the chain reactions which can occur in the supply-demand situation. Until recently resource problems could be explained in binary terms — supply and demand could be considered for one resource at a time. But, cross substitution issues relative to the direct supply and demand issues can no longer be neglected. For example, when the anchovy fishery disappeared temporarily off Peru, the Japanese developed an enhanced interest in the American soybean market because they needed a substitute feed for beef. Soybean prices skyrocketed, and the U.S. imposed an export ban. Those chain reactions occur even more frequently when environmental problems are also considered. When the E.P.A. put low-sulphur requirements on emissions from coal-fired power utility plants, there was a sudden shortage of railroad cars as well as a tremendous growth in strip mining of low-sulphur, western coal. At the same time the slackening demand for high-sulphur, eastern coal helped to provoke the bankruptcy of the Pennsylvania Railroad — a chain reaction of events resulting from a sudden intervention in the supply-demand situation.

The striking example of this point could be the so-called Inter-Agency Energy Study, published in 1966. The main conclusion of the study was that no shortage of energy in the United States would occur before the end of the century. The figures behind that statement indicate that the inaccurate forecasting was on the side of demand, not supply. Indeed, the forecast supply turned out to be almost exactly right, but by 1972 the demand for imported oil was between 15 and 18 per cent greater than the demand which had been forecast in 1966. The reasons for this are myriad: heavier automobiles; pollution controls; the conversion of utilities from coal to oil particularly in the Northeast; the large-scale installation of gas turbine oil-fired peaking power generation (which turned out to be base-load generation because of the delays in the installation of nuclear power plants); and so on. Case after case of interacting events made the estimate of fuel consumption completely wrong in only six years. Since 8 to 15 years are required to put a major energy supply source on line, this is a serious matter. A discontinuity in demand was enough to invalidate previous projections and cause serious shortages of certain fuels even before the oil embargo and O.P.E.C. price increase.

The Political Benefits of Growth

The great virtue of economic growth in the past has been that it softens difficult political conflicts over the division of the nation's products. The benefit lay not so much in conventional statement, that the poor could see their condition improving, as in the opportunity for upward mobility of a few which economic growth presents. The fact that a fair sample of the working class in each generation were able to move up into the professional and technical class was probably more important than the upgrading of the average standard of living of the poor. It was the examples of escape into relative affluence which made

Results of the Unequal Divvy: A Resource Forecast

Approximately 30 per cent of the world's people hold 80 per cent of the world's income. Logical, then, that 70 per cent of the world hope their children can someday join the affluent elite. The opportunity for upward mobility, says Harvey Brooks (*see opposite*), is the carrot that makes gross inequalities palatable.

From 10 to 30 millions cross the threshold from poor to middle class each year, according to Nathan Keyfitz, Andelot Professor of Demography and Sociology at Harvard University. If automobiles are a relevant yardstick, he figures that 90 per cent of the people in the U.S. and Canada, 40 per cent of those in Western Europe and Japan, and 25 per cent of the people in the Soviet Union — automobile owners and users all — are affluent. These drivers, numbering half a billion, require three metric tons of crude oil per year per person, on and off the jobs which supply their comforts.

The number of fuel-hungry affluent is increasing by 5 per cent per year, doubling every 14 years, said Dr. Keyfitz. "The expanding participation in high consumption" — the demands of an increasing middle class — underlies the shortages of fuel and meat in the U.S. and elsewhere, he told the Pacific Science Conference in Vancouver, B.C.

While the world's resources easily provided 200 million American consumers with the daily conveniences they take for granted, providing 700 million people with the same luxuries is proving difficult. "What this means for the prospects of the remaining 3,300 million already on the planet, and the additional 2,500 million or more who will be here in the year 2000, is the vital question for the global future," Dr. Keyfitz said.

With a hat tip to the hazards of prediction, Dr. Keyfitz described three scenarios. Which combination of the three will come to pass is up to us, he said:

— Those countries with small populations and large resource reserves, such as the Arab states and the U.S., will be the masters. Nations with large populations and inadequate resources will suffer intermittent starvation, relieved now and then by the largesse of more powerful nations.

"War has been the classical way of adjusting such imbalances from the beginning of time," warned Dr. Keyfitz. The overwhelming consequences of nuclear war will limit national policies to threats and hard words, he hoped; or

— Those countries with scientific and technical know-how will discover clean, fully-controlled atomic fusion, which will make energy so cheap that ordinary rock and sea water can be mined for the resources they contain. In this scenario, nations outflank the resource shortage by technological innovation. With no shortages, the world can concentrate on cleaning up the problems these new technologies will cause; or

— Affluent nations will retreat from the energy economy and shift from energy-intensive to energy-conservative means of production, transportation, agriculture, etc. Subsidies for airlines will be replaced by subsidies for the arts. This redirection will begin in countries whose appetite for energy has been the largest. "Some few good signs were already visible in 1975," said Dr. Keyfitz. "In 1975, 14,000,000 bicycles were sold in the U.S., compared with 10,000,000 cars."

Employment and production, as well as consumption, are the roadblocks here, he said. "For people to stop driving cars is hard enough; to stop making them when that is a person's life work, source of self-respect, principal means of integration into the social system, is to be a martyr to the environment."

In summary, said Dr. Keyfitz, "inequality of income, which has all along been serious because of unequal distribution of capital, will become more serious because of unequal distribution of resources. Population increase will exacerbate these tendencies."

But population control alone will not relieve economic inequities: resource shortage, inadequate technology, and "the unwillingness of those in high-energy economies to change their mode of life" stand in the way. — *S.J.N.*

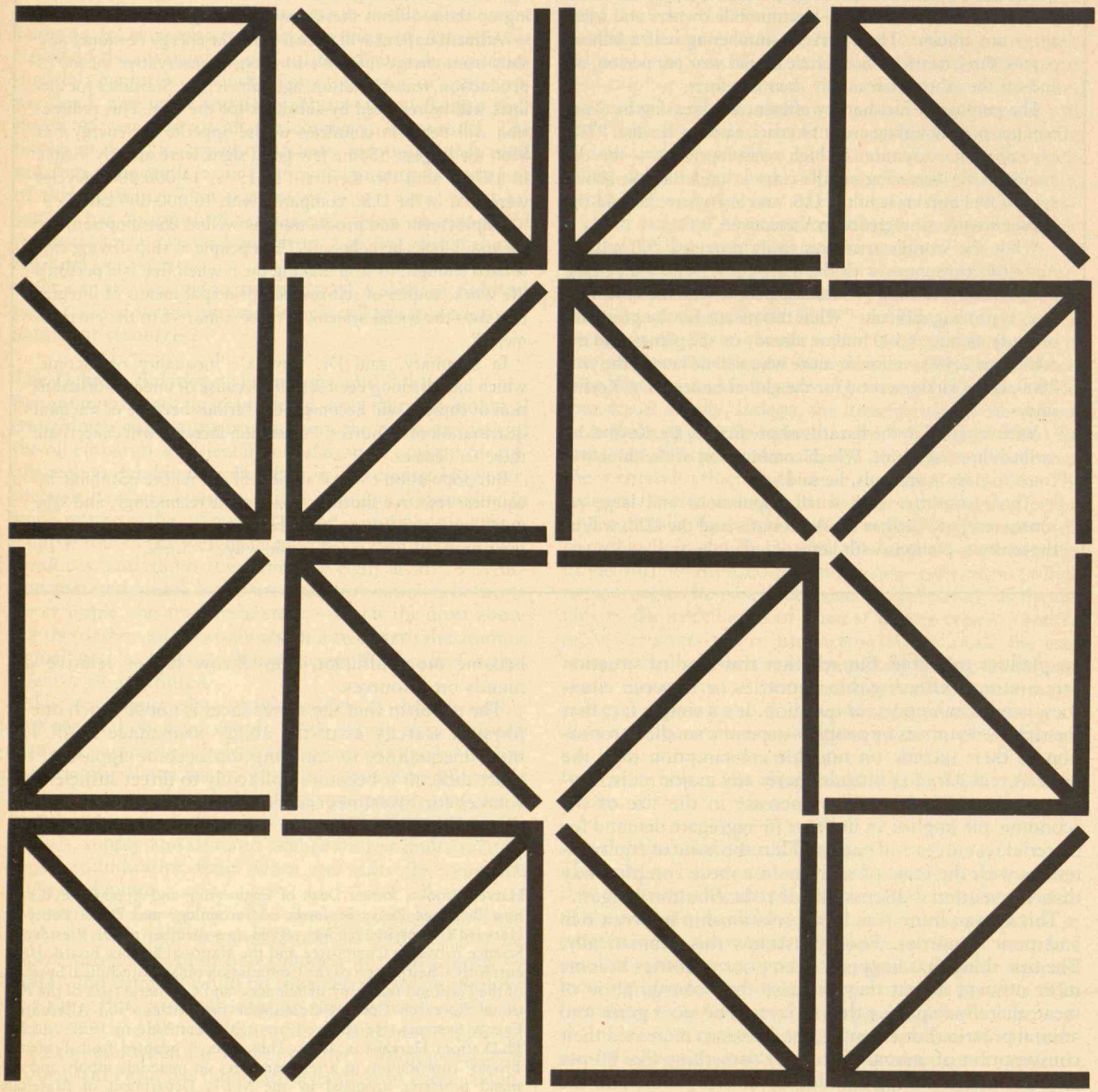
inequalities tolerable. But whether this kind of situation can continue, either within countries or between countries, is now an important question. It's a simple fact that the rich — countries or people — spend a smaller proportion of their income on tangible consumption than the poor. A real paradox intrudes here: any major redistribution of income without any increase in the size of the economic pie implies an increase in aggregate demand for material resources and energy. Thus the issue of equity interacts with the issue of scarcity in a more complex way than conventional discussions of redistribution suggest.

This is even more true in the relationship between rich and poor countries. Food illustrates this dramatically. The first thing that happens when poor countries become more affluent is that they increase their consumption of meat, thereby requiring the conversion of more grain into animal protein. For example, the Russians increased their consumption of animal protein by something like 80 per cent per capita during the decade of the 1960s, and the Japanese increased theirs by 150 per cent. So, as the poor become more affluent, they throw higher relative demands on resources.

The problem that the world faces is not so much one of physical scarcity as of the ability to manage itself. The more inequalities in consumption become apparent, the more difficult it becomes politically to direct sufficient resources for investment in the future.

Harvey Brooks, former Dean of Engineering and Applied Physics, is now Benjamin Pierce Professor of Technology and Public Policy at Harvard University. He has served as a member of the President's Science Advisory Committee and the National Science Board. He is currently Chairperson of the Commission on Sociotechnical Systems of the National Academy of Sciences, and Cochairperson of the National Research Council Committee on Nuclear and Alternative Energy Systems. He received his A.B. from Yale in 1937 and his Ph.D. from Harvard in 1940. This paper is adapted from Professor Brooks' contribution to a seminar series on materials supply and demand problems arranged by the M.I.T. Department of Materials Science and Engineering in 1975.

Research and development workers learn most of their new ideas by talking. The effective R & D laboratory is designed to allow engineers and scientists freest access to one another.



Thomas J. Allen and Alan R. Fusfeld
Sloan School of Management
M.I.T.

Design for Communication in the Research and Development Lab

We know that good communication among its participants is essential to effective research and development work; the quality of a research and development organization is highly dependent upon good interpersonal communication. And we know intuitively that the shape and organization of the buildings in which they work strongly influences the patterns of interaction among the inhabitants. It follows that patterns of communication in a research laboratory should be an important criterion in its physical design.

But in spite of the self-evident nature of this conclusion, one does not have to visit many research and development establishments to realize that these principles are observed in the breach, if at all. Even an extensive search throughout the U.S. yields few examples in which the architectural design involves a conscious attempt to promote intramural communication.

Two reasons underlie this apparent neglect. Though most managers would concur in the importance of communication, it is only recently that its true significance has been demonstrated convincingly by empirical research; most architects have therefore been unaware of the true importance of communication among the occupants of research laboratories. In addition, until recently there has been very little research on the nature and sensitivity of the relationship between physical layout and communication within buildings, and none of this until the present time has dealt with research laboratories as a specific case.

Correlating Communication and Performance

A large number of studies have shown that organizational communication strongly influences the effectiveness of research and development performance. *(See, for example, "Communications in the Research and Development Laboratory," by Thomas J. Allen in* Technology Review *for October/November, 1967, in which the present author showed that engineers who obtain ideas from organizational colleagues and who consult more within their organizations produce better technical solutions.)* Subsequent research has further confirmed a strong, positive correlation between intra-organizational communication and the research and development performance of scientists and engineers.

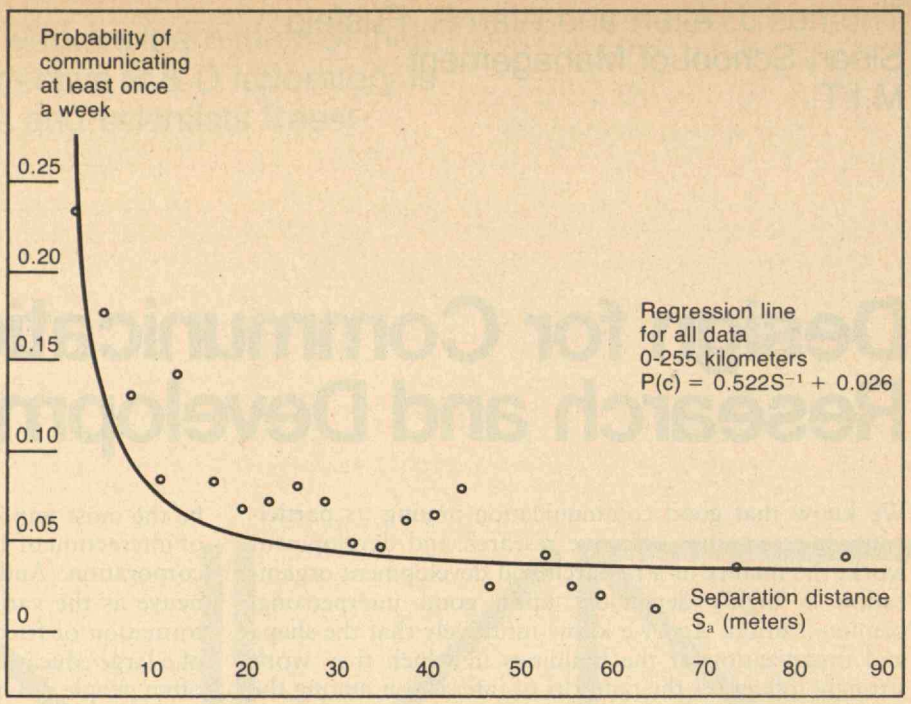
There is also a long history of research to demonstrate the effects of location on human interaction. For example, several studies have shown that an implicit network which influences the interaction patterns of a group is inherent in its seating arrangements. Distance was found to be the most important factor in determining the pattern of interaction of 12 women in the office of a large eastern corporation. And propinquity is described by Maisonneuve as the variable which significantly influenced the formation of friendships among students in a classroom of a large educational institution; he concluded that "very often people did not get closer to each other because they had a liking for each other, but they are inclined to have a liking for each other because they are close to each other."

What can be done to improve communication?

Improving Communication Architecturally

The purpose of our research was to suggest how, if at all, intramural communication could be promoted by the architectural design of a research and development laboratory. We chose seven research and development laboratories in which to measure communication patterns, either by asking individual engineers and scientists to indicate the organizational colleagues with whom they communicated "about technical or scientific matters" at a frequency of once a week or more, or by sampling communication with a questionnaire administered weekly on randomly chosen days. A total of 512 respondents were sampled to determine their communication patterns during periods of from three to six months. From this data we determined which pairs of individuals maintained regular communication at an average frequency of at least once per week.

The laboratories ranged in size from 48 to 170 professionals; two of the laboratories were in the aerospace industry, two were in universities, one was in the chemical industry, one was in the computer industry, and one was a government agricultural laboratory. In the first six cases distance was measured from desk to desk, in the seventh from building to building. In all cases, each engineer or scientist was taken, in turn, as a focal person, and the actual walking distance from his or her desk to that of every other engineer or scientist in the organization was recorded. These distances were then aggregated in intervals of 3 meters, and for each such interval the ratio was computed of the number of individuals with whom the focal person communicated to the total number of people available. Such a ratio can be computed for any frequency of communication; the present analysis is based upon an average frequency of one or more communications per week, a unit of time chosen arbitrarily to represent quite regular and consistent communication. The ratio represents, on the average, the proportion of available people



The probability that two people will communicate as a function of the distance separating them. The authors studied the relationship between the communication patterns of professional people and the separation of their offices in seven research and development organizations to obtain the data shown here. Though intuition suggests a curve of this shape, the fact that the probability of communication falls so rapidly as separations approach only 10 meters was surprising — and served to emphasize the importance of these studies.

with whom an individual communicates at a given distance and frequency.

Intuition suggests that the probability of communication would decrease with distance, perhaps at a more than linear rate. But the actual rate of decay which we found is surprising: the probability of weekly communication reaches a very low level when the distance is only 25 or 30 meters. It is this extraordinary rate of decay that is so startling: only for people within 30 meters of each other does separation have any real effect on the probability of commnication!

The Effect of Organizational Bonds

One possible objection to this analysis is that space in most organizations is allocated on a group basis; people of similar backgrounds or those working on the same or similar tasks are located near each other. If this is so, then any individual, for organizational reasons, is more likely to communicate with those nearest to him; the decay in communication with distance is simply an artifact of organizational location.

To test this possibility, the data from one of the seven laboratories were separated into two groups, and separate patterns of communication in relation to distance were computed for pairs who shared an organizational group affiliation and for those who did not. The two results show that common group affiliation does indeed increase the absolute likelihood of communication, but the distance effect still operates in the same manner. The probability that an individual will travel a given distance to talk with someone in his group is slightly higher than the probability for someone in a different group; the presence of the group bond merely introduces a relatively constant positive bias, itself independent of distance.

Office Arrangements: The Lesson for the Architect

These results have a very clear message for those who are responsible for the design of research laboratories.

The classical approach of arraying offices in a linear fashion along a linear hallway maximizes the separation of offices and is hardly the best way to promote communication; to minimize separation, one should approach a circular or square configuration.

Many research and development complexes, which look like an alphabet soup with buildings whose plan view is a connected series of H-shapes, result from a desire to give everyone an outside exposure. While it is very nice to be able to see outside of one's building to observe the changing weather and seasons, we now understand the cost associated with this plan and we can emphasize other ways to permit this without causing the isolation produced by elongated shapes. There are many obvious possibilities: hallways can be moved to the exterior walls and windows opened along them; common areas, such as libraries, meeting rooms, and coffee lounges, can be given the outside locations with windows.

One thing is certain: the head of an organization who wants to keep in close touch with what is going on must resist the temptation to locate in the corner with the best view. The center of the building is the best place.

Vertical Separation: Three Stories but Never Two

What about the effect on communication of vertical separation in a building? Many factors, in addition to actual distance, are involved. The location of stairs or elevators, their accessibility (for example, whether stairs must be protected by fire doors), and the amount of visual contact that they allow, all enter in.

Available data indicate that vertical separation jeopardizes communication at least as much as horizontal separation. In most office buildings, the actual length of the stairs between two floors is between nine and 15 meters, so it is reasonable, on the average, to assume a one-story separation to be at least equivalent to that amount of horizontal separation. Elevators do not seem to change this situation in the case of one or two floors; people are just about as reluctant to use an elevator as to climb stairs.

Number of communications between research and development groups			
Communication between	and	Communications per potential pair per week	
		Before	After
Molding materials	Permeable materials	0.35	2.89
	Fiberloy	1.74	2.49
	Printing materials	—	0.75
Permeable materials	Fiberloy	2.77	3.81
	Printing materials	—	0.23
Fiberloy	Printing materials	—	4.89

The number of communications between four groups of Laboratory "G" 's research and development department increased markedly after the groups were assembled in a simple, new facility, though the new Printing Materials group remained somewhat isolated when these data were taken. There is a special explanation for the relative lack of improvement in communications between the Permeable Materials and Fiberloy groups, the authors reported: the new building imposed a "people barrier," the new Printing Development group having been placed between the Fiberloy and the Permeable Materials offices. The barrier was particularly effective because the Fiberloy and Permeable Materials laboratory were near their respective office areas and at opposite ends of the building, and so the two groups never were forced to cross the barrier. In this case, said the authors, special conditions in the post-move arrangement may have more than offset the advantage of closer proximity.

An Experiment in Laboratory Design

Many of the ideas in the accompanying article were refined and tested through work with Laboratory "G," the research and development department of a small chemical firm which in 1967 was planning the construction of a new research facility. The architects for this new facility produced a design which minimized physical separation while providing for privacy and made use of laboratory space assignments to offset whatever office separations were necessary, and the management of Laboratory "G" agreed to help us determine whether the new facility design accomplished its intended goals by permitting communication measurements both before and after moving into the new facility.

Laboratory "G" Before the Architectural Change

Prior to the opening of the new laboratory building, three Laboratory "G" research and development groups (Molding Materials; Permeable Materials; and Fiberloys) had laboratory space and pilot-plant facilities in a main plant building originally built in the mid-19th century to house a textile mill. Offices and laboratories of each group were arranged in clusters, and routes between these cluters traversed production and inventory areas.

The Molding Materials and Fiberloy Groups were located on the same floor, roughly 85 meters apart. The Permeable Materials Group was separated from the others by two floors. A 40-foot staircase contributed part of the 34 meters separating Permeable Materials from Fiberloys as well as part of the 104 meters separating Permeable Materials from Molding Materials.

The communication network of this organization in the old facility clearly reflected the spatial arrangement. Analysis of communication patterns showed that the three principal groups were not in close communication. Direct communication was adequate between only two of the groups; Molding Materials, especially, showed the effect of its isolation.

Laboratory "G" in Its New Arrangement

As the three groups were moved to the new facility, a fourth group — Printing Materials — was added, formed partially out of the Fiberloy Group. All four groups were on the same level surrounding a common lunch room in the new building, with mean distances between offices of 22, 19, 15, and 14 meters. This change represented a mean reduction in intergroup distance of about 73 per cent.

This was the most significant single effect of the new facility, and it had the predicted effect of substantially improving communication among the groups. Unfortunately, the data are complicated by factors related to the new group (Printing Materials) plus transfers and turnover among the staff; but there can be little disagreement that intergroup communication was increased. As the table shows, the number of people having weekly contact increased substantially for two of the group pairs and remained essentially constant for the third. In all three cases, there was an increase in the number of communications per potential communication pair per week.

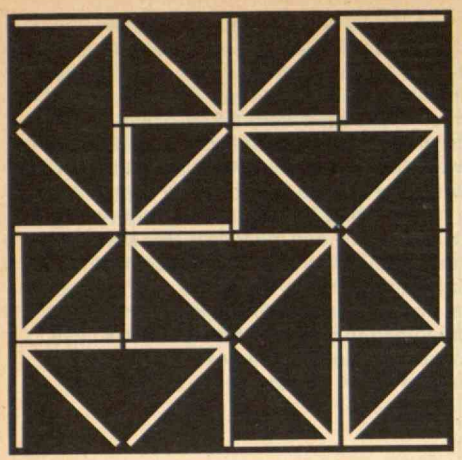
Each of the four groups was assigned a laboratory area, two groups to each side of the building; thus Printing Materials and Permeable Materials share a laboratory, as do Molding Materials and Fiberloy. Contrary to prediction, however, the sharing of a laboratory area did not promote inter-group communication. As a matter of fact, those organizations with both shared laboratories and adjacent offices turned out to have the weakest average communication bond. Communication appears to occur most easily in the "x" direction, and we postulate that this is the result of some other facility which tends to draw people in that direction, perhaps the lunchroom. The results are ambiguous except on one point: little can be said for shared laboratory space as a promoter of communication.

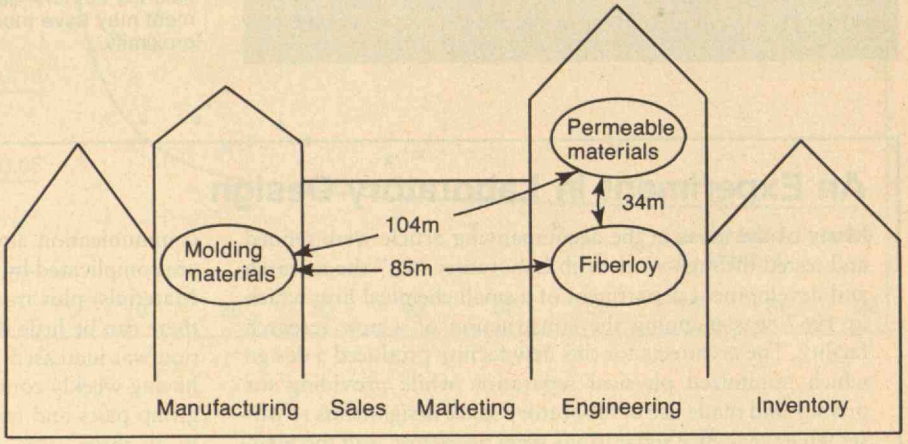
For Every Gain a Loss

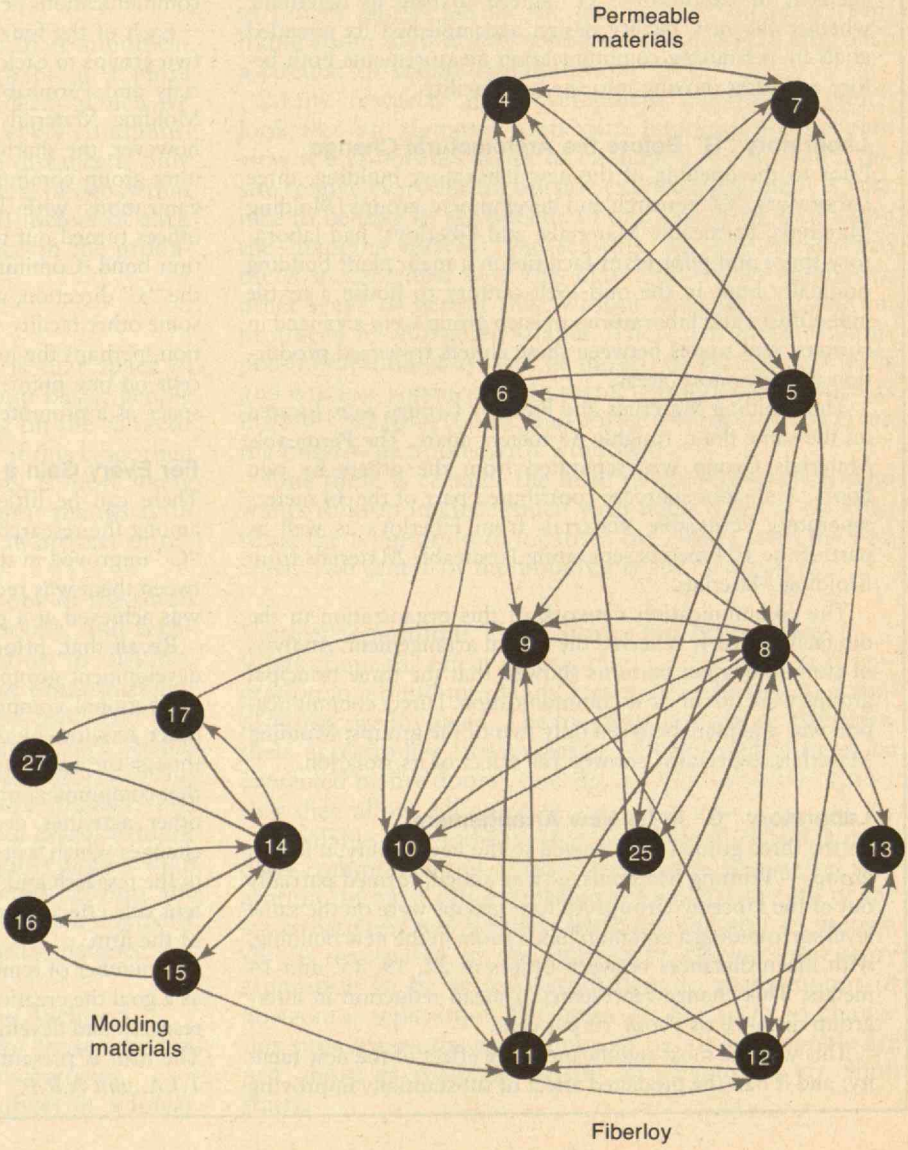
There can be little doubt that in general communication among the research and development groups in Laboratory "G" improved in the new facility as physical separation between them was reduced. But this improved communication was achieved at a price.

Recall that, prior to the move, the various research and development groups were located in the midst of other organizational components; they were separated from these other activities by the move into the new research center. Although the actual distances were never measured, it was clear that communications between research and development and other activities decreased as a result of the move. The changes which were introduced to improve communication in the research and development laboratory had the inadvertent side effect of reducing communication with other parts of the firm.

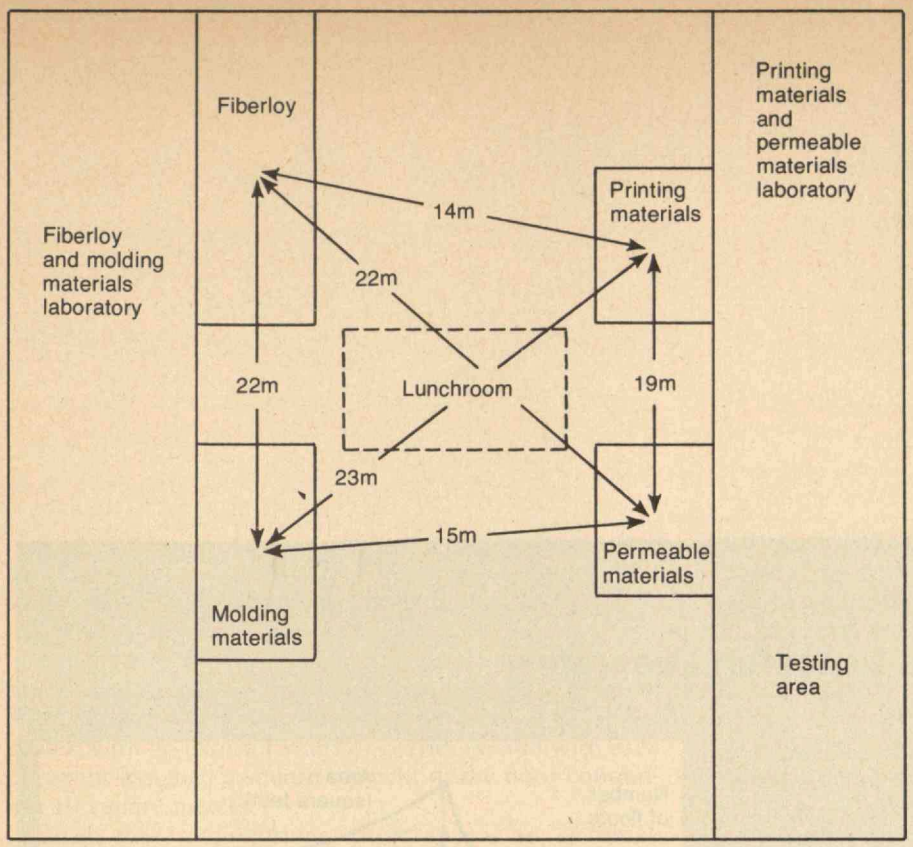
A number of remedies can be proposed, all of them having as a goal the creation of reasons for people to move between research and development and the other departmental areas. The firm is presently experimenting with some of these — *T.J.A. and A.R.F.*

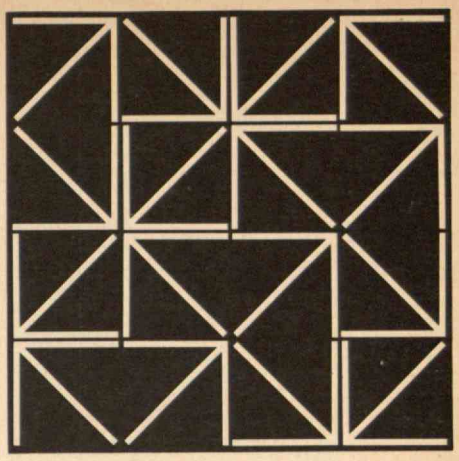


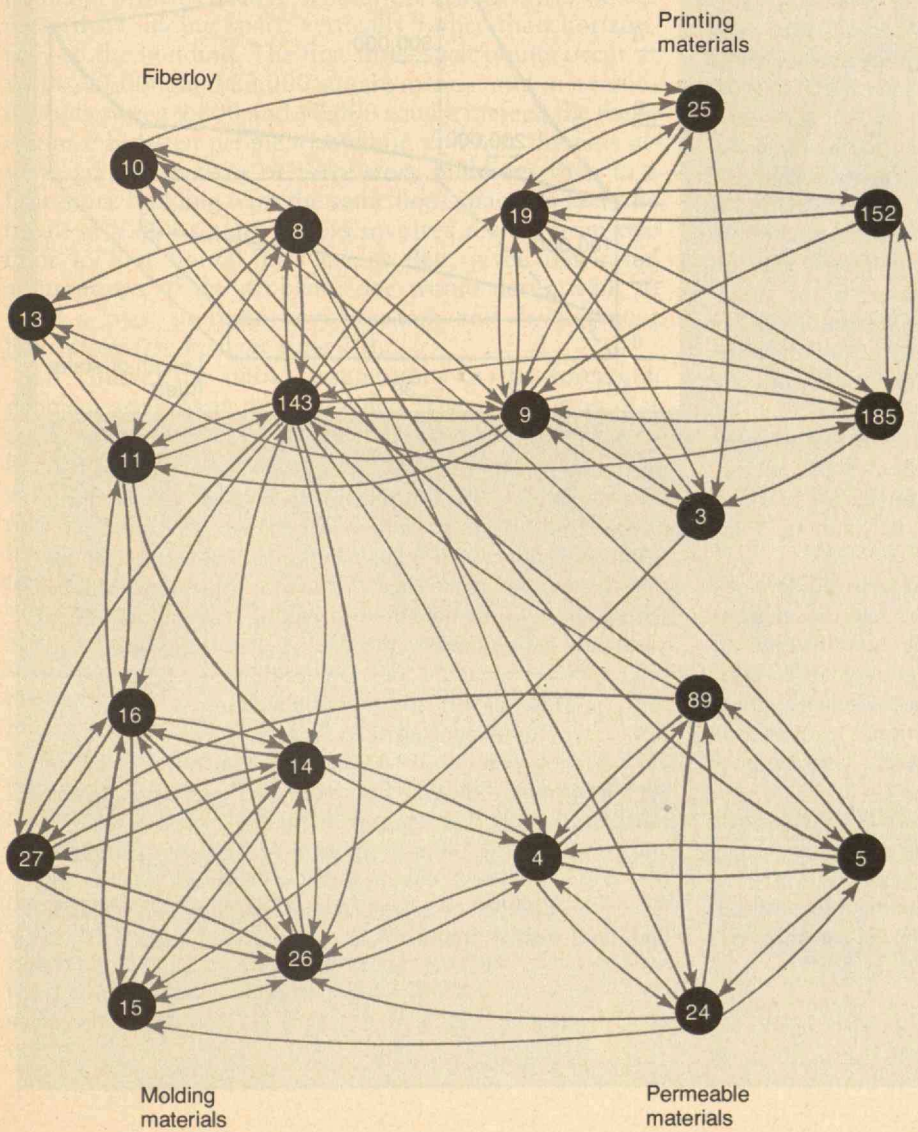




Before a new research building was completed, three research and development groups in a small chemical firm were located in three separate clusters of offices and laboratories each surrounded by other company activities — manufacturing, marketing, sales, engineering, and inventory — as shown at the top. The pattern of communications among professional members of these groups is shown below — each arrow representing one or more communications per week between the individuals shown. The three groups were of roughly equal size, and the isolation of the Molding Materials group is especially obvious.



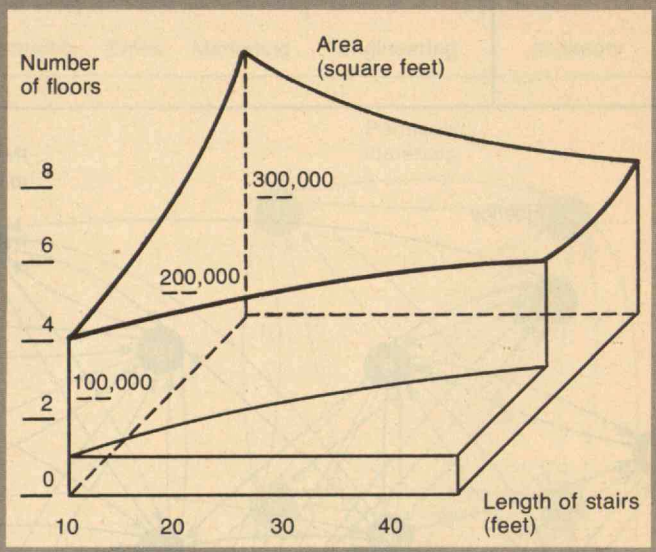




Four groups were created out of three earlier groups when Laboratory "G" 's research and development department moved into its new quarters (above). Communication between three of the four groups was promptly enhanced by the new layout, in which the four groups shared two laboratories and a common lunchroom and where their physical separation was markedly reduced. Each arrow on the chart below represents one or more communications per week among the individuals shown. The fourth group — the new one, Printing Materials — was still in the process of joining into the communications process; its members were in touch effectively only with the Fiberloy Group, from which some had been drawn. The authors assumed that the situation would correct itself with time and that the new facility would be helpful in accomplishing this.

The Optimal Height of a Research Laboratory

In its impact on communication, vertical separation is at least as severe as horizontal separation. Yet as floor area increases, at some point people will be closer together in a multi-story building than they could be in a single-story building. Considering only the criterion of communication, at what point is it better to build a multi-story building than a single-story building with the same floor area? After making some simplifying assumptions — a square building divided into desk areas 10 square meters each, no allowance for internal walls or corridors, and (when needed) a single staircase in the center of the building — an analysis has been made of the mean distance between pairs of individuals uniformly distributed throughout a building as a function of the total available floor space, the number of floors, and the length of stairs between floors. The result is the three-dimensional plot (at right) showing the number of floors required in a building of given floor area to minimize the average distance between pairs of individuals who are distributed uniformly throughout.

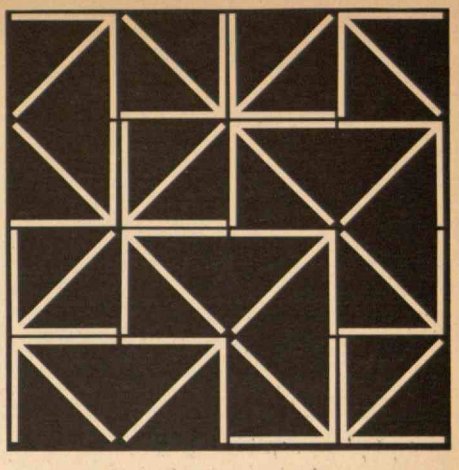


The surface indicates that for buildings with stairs longer than 3 meters, the optimum number of floors is one and, as the area increases, four, five, six, etc. It is interesting that two and three floors do not appear among the optimum solutions.

All of this suggests that planners of research and development facilities should be cautious about selecting designs with two or three floors; such designs cannot result in minimizing the distance between pairs of individuals. In turn, this means that communication cannot be maximized unless there are other architectural or organizational features that compensate for the increased average distance between people in a two- or three-story design.

There are a variety of mechanisms that will provide such compensation and, in fact, be useful in any multi-story structure. These include the forced sharing of facilities located on different floors, organizational bonds spanning floors (offices of supervisors on one floor and their technicians on another), open and easily accessible staircases (or better yet, escalators), and rotation of individuals between groups. Each of these will help to provide increased communication.

But in making such adjustments, let planners remember that the unsatisfactory effects of two or three floors will be felt by any two- or three-floor grouping in a multiple-story building. One response to this could be to arrange groups to be either solely on one floor or on four or more floors where they are close to the interfloor connections. A second approach would be to locate different groups that should be in close communication on four or more floors and to locate support groups at the extremities of each floor. Care must be taken in choosing which groups should be in close proximity and which are truly support groups. An obvious example is the need for good communication between marketing groups, library resources, and research groups of a research and development organization. — *T.J.A. and A.R.F.*



As floor area increases, a point clearly must be reached at which the average separation between offices in a single-story building exceeds that in a multi-story building of the same area.

An oversimplified example of our results in seeking this break-even point can be pursued by assuming a square building with a staircase whose length is 12 meters in the center, with no exterior walls or corridors, and with each occupant assigned a square segment of the floor containing 10 square meters.

Given these assumptions, there appear to be break points at which effective separation distance will be decreased by adding space vertically rather than horizontally to the building. The first three such points occur at 9,800, 17,000, and 23,000 square meters; and in a building of between 9,800 and 17,000 square meters, the mean distance between people located on *different* floors is always greater in two- or three-story buildings than in a four-story building with the same floor space. In fact, the break at 9,800 square meters involves a shift from one floor to four floors! This means that, given the initial assumptions of the problem, one would never want to build a two- or three-story research and development laboratory (*see box on page 70*).

Of course, the initial assumptions in the foregoing problem are grossly oversimplified. The assumption that a 12-meter staircase has the same effect as 12 meters of horizontal separation accords with the data reasonably well for a single flight of stairs; but it is probably not correct to assume that the relationship is linear — that two flights are equivalent to 24 meters, three flights to 36 meters, and so on.

To see what happens when one tries to account for this, assume again that the separation between the first and second floors is 12 meters, but that the distance between the first and third floors is 2.25 times that distance, three flights are equivalent to 3.75 times one flight, four flights to 5.50 times one flight, and so on. The first three break points now occur at 9,000, 18,000, and 36,000 square meters; the first shift is from one to three floors, and one would still never want a two-story building.

The simplified conclusion from this analysis is that, for communication purposes, a research manager would want to limit the laboratory to a single-story square building as long as the total required floor space is less than 10,000 square meters. Above that area, the building should have at least three floors, and elevators should be used.

Interaction-Promoting Facilities

Traffic patterns in a building have a direct effect on communication; they both promote chance encounters and aid in accomplishing intended contacts. Much of the traffic in a building is made up of people moving to and from certain common facilities — washrooms, copying machines, coffee pots, cafeterias, computer consoles, laboratories, special test equipment, supply rooms, and conference rooms, for examples. It is clear that such common facilities can be deliberately used to increase chance encounters among occupants and promote intended contacts by providing people with more than one reason for traveling in a particular direction.

Locating everyone on the same floor within a 30-meter circle is seldom possible, but a strategically located laboratory or copying machine shared by two groups whose physical separation might otherwise inhibit communication is a good alternative. The possibilities here are endless, and little imagination is required to locate and assign facilities and groups in ways that increase desired interaction.

Communications and Architecture

There is strong evidence that effective communication is a determinant of effective performance among scientists and engineers in a research and development laboratory. Though some details of cause and effect are unresolved, our studies show very clearly that communication among research groups is influenced strongly by the physical, architectural arrangement of the facilities in which they work; especially we know that communication between individuals is very sensitive to both the horizontal and vertical distances which separate them.

These results should form the basis for further experiments and analyses of architectural arrangements to reduce effective separation. The possibilities are almost limitless.

In 12 years since coming to M.I.T. for graduate work in the Sloan School of Management (S.M. 1963, Ph.D. 1966), Professor **Thomas J. Allen** has made important studies of how effective communications correlate with innovative research and development work in various laboratory and national settings. He brings to this work the advantage of a background in science (B.S. in physics, Upsala College, 1954) and five years' experience in research and engineering at Boeing Co. **Alan R. Fusfeld** is working with Professor Allen as a doctoral candidate at the Sloan School and is also working with Pugh-Roberts Associates, Inc., Cambridge. The present article is adapted from an earlier publication in the British journal *R & D Management*.

Classified

PROFESSIONAL

PUBLICATIONS

VACATIONS

Puzzle

Continued from p. 29

O/N 4 L. J. Upton has pointed out that the solution given can be generalized to an arbitrary number of rivers.

Y1975 Ronald J. Brinkerhoff has responded, and Dr. Harry Hazard has found the following expressions with 1, 9, 7, and 5 in order:

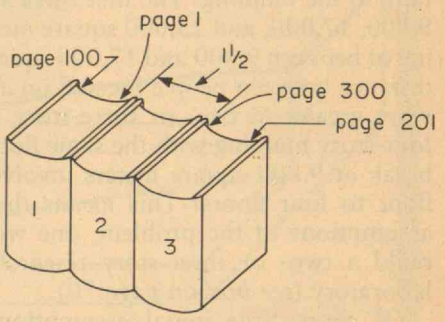
1 1 ** 975	44 (1 * 9) + (7 * 5)
5 (1 ** 97) * 5	45 1 + 9 + (7 * 5)
7 19 − 7 − 5	54 19 + (7 * 5)
11 (1 * 9) + 7 − 5	67 1 − 9 + 75
17 19 − 7 + 5	69 1 + (9 * 7) + 5
19 1 + (9 * [7 − 5])	75 (1 ** 9) * 75
21 19 + 7 − 5	81 (1 * 9) ** (7 − 5)
22 1 + 9 + 7 + 5	84 1 * (9 + 75)
27 1 − 9 + (7 * 5)	85 1 + 9 + 75
31 19 + 7 + 5	92 1 * (97 − 5)
32 1 * ([9 − 7] ** 5)	93 1 + 97 − 5
33 1 + ([9 − 7] ** 5)	94 19 + 75
36 (1 ** 9) + (7 * 5)	

NS1 Philip O. Martel has some partial results similar to those which appeared in 1966-67.

DEC 4 S. P. Hirshman has responded.

Proposers' Solutions to Speed Problems

SD1 Answer: 1.5 inches. The drawing shows that the worm eats through four covers and 100 pages.



SD2 The total distance from the first vessel to any point on shore and then to the second vessel would be the same if the second vessel were located nine miles inland. But if the second vessel were nine miles inland, the shortest distance would be a straight line which is $[(3 + 9)^2 + 5^2]^{\frac{1}{2}}$, or 13, miles. Thus the boat leaving the first vessel travels toward an imaginary vessel nine miles inland until it reaches shore and then travels to the other vessel for the minimum distance of 13 miles. (Note the similarity to O/N4. — Ed.)

Allan J. Gottlieb, who is Coordinator of Computer Activities at York College of the City University of New York, studied mathematics at M.I.T. (S.B. 1967) and Brandeis (A.M. 1968, Ph.D. 1973). Send problems, solutions, and comments to him at York College, 150-14 Jamaica Avenue, Jamaica, N.Y., 11451.

Institute Review

In This Section

The Chemical Engineering Department celebrates its new Ralph Landau Building with a symposium, a dedication, and two professorships ..... **pages 73 to 78**

E.R.D.A.'s first institutional award ($1.5 million this year, more in the future) comes to the Energy Laboratory ..... **page 79**

After its first 100 years, what of the telephone — its past, its present, and its future? M.I.T. joined A.T.&.T. in a centennial Convocation on Communications ..... **page 80**

What's going on in Cambridge? A collection of miscellanea to answer that question: Student apathy? Dorm problems? Engineers for Taiwan? What future for Star Trek? ..... **pages 81 and 82**

Mexican managers hear it from the Sloan School ..... **page 83**

How the great Guatemala earthquake was felt in Westford, Mass. ..... **page 85**

Winter sports: a "highly commendable" record ..... **page 89**

Scenes of spring — it finally comes, every year, along the Charles ..... **page 91**

After 70 Years of Leading, M.I.T. Chemical Engineers Assess the Future: Plenty of Unfinished Business

Seventy years ago the profession of chemical engineering was being invented at M.I.T., and since then it has been shaped by the profound contributions of a remarkably productive faculty ... William H. Walker, Warren K. Lewis, '05, Robert E. Wilson, '16, William H. McAdams, '17, Walter G. Whitman, '17, Thomas K. Sherwood, Sc.D. '29, Hoyt C. Hottel, '24, Edwin R. Gilliland, Sc.D. '33 ... Perhaps no other department at M.I.T., and no other chemical engineering department anywhere, is more closely associated with the development of the profession it serves.

Now the profession and the Department (in its new $14.6 million Ralph Landau Building, a graceful if unconventional accent north of the East Campus parallels) confront a new set of problems. Speakers and alumni who returned for ceremonies dedicating the new building on March 4 and 5 agreed: the new problems are different by an order of magnitude from those of the past.

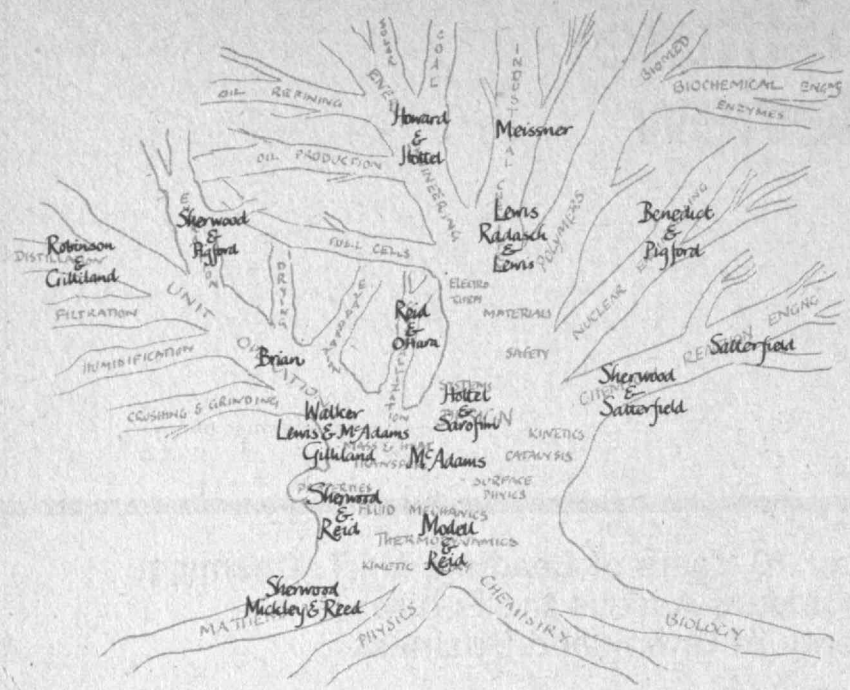
What will be the critical future tasks for members of the profession of chemical engineering? Here are answers from seven speakers at the dedication convocation:

Energy. The U.S. does not yet appreciate the seriousness of its energy supply problems, said Maurice F. Granville, S.M. '39, Chairman and Chief Executive Officer of Texaco, Inc. Heavy reliance on imported petroleum — he forecast that up to 70 per cent of U.S. consumption might be imported by late in the 20th century — poses "unacceptable risks for the national security and economic well being of our country," Mr. Granville said, and he called for rapid development of domestic resources and of new chemical processes to use them.

Nuclear power. Each 1,000-Megawatt nuclear power plant we build represents a saving of 35,000 barrels of oil a day, 10 million barrels a year, said Edward A. Mason, Sc.D. '50, Commissioner of the U.S. Nuclear Regulatory Commission. The challenges for engineers are to maintain the record of nuclear safety, to control nuclear plant construction costs, and to extend raw material supplies by achieving a successful breeder reactor.

Environmental integrity. Everyone now recognizes the need to reduce pollution and environmental impacts of all kinds — and many people realize that chemical engineers have a big part of the job to do. But don't think of environmental integrity as an unproductive distraction from the main tasks at hand, said Robert E. Siegfried, S.M. '47, President of the Badger Co., Inc. Environmental regulations are in fact generating new, more efficient technologies, he said, and new plants now being designed "will require a smaller percentage of expenditures for environmental controls while realizing increased recovery of materials and energy." For example, 15 years ago oil refineries lost as air pollutants some 0.6 per cent of the crude oil processed; a new, modern refinery will lose only about 0.1 per cent, and the saving represents an additional 65,000 barrels per day of recovered products based on the total crude oil being processed today in the U.S., said Mr. Siegfried.

Life sciences. A fundamental interest of chemical engineering is in "the complex interrelationships of physical and chemical forces operating on molecules," and that interest is as fruitfully applied in the life sciences as in the physical ones, said Edward W. Merrill, Sc.D. '47, Carbon P. Dubbs Professor of Chemical Engineering at M.I.T. The chemical engineer can make special contributions, he said, to biological/physiological systems that involve molecular separation and transport, and chemical reactions simultaneously with diffusion. "Thus he becomes an engineer of biochemistry," said Professor Merrill, who continued with examples of his own work on artificial kidney function, the membrane



If chemical engineering is represented as a widely branching tree growing from four tap roots of mathematics, physics, chemistry, and biology, landmark textbooks from the M.I.T. Department of Chemical Engineering span every trunk and branch, beginning with Principles of Chemical Engineering *by William H. Walker, Warren K. Lewis, '05, and William H. McAdams, '17, in 1923. The diagram was used by Rutherford Aris, Head of the Department of Chemical Engineering and Materials Science at the University of Minnesota, to illustrate his tribute to the Institute during a convocation on "The Future of Chemical Engineering" on March 4 and 5.*

lung, the artificial pancreas, and the delivery of pharmaceuticals.

Third-world aspirations. Many developing countries now want the benefits of industrialization, and they are pressing for larger shares of the manufacturing by which their raw materials are turned into goods for the world market. "I have no question that the engineer of the future will be faced with the complex problem of dispersing his productive capacity around the world to an extent not heard of today," said Roger E. Drexel, Sc.D. '46, Vice President of E. I. du Pont de Nemours and Co., Inc. "This will mean smaller, less efficient plants operating under different economic conditions."

Inflation. Rising prices — especially of high-technology products and facilities — will put new constraints on the methods and products of chemical engineers. Dr. Drexel again: "During a period of 20 per cent annual inflation of construction costs a one-year delay to optimize a key portion of the project (saving 50 per cent on 10 per cent of the total investment) has the overall effect of increasing the total investment in the project 14 per cent. Inflation demands that the perfection which most professionals cherish be measured against the time value of money."

Competition. In 1950, the U.S. produced two-thirds of the world's goods; now we make only one-third. In 1950, three-quarters of the world's research and development was carried out in the U.S.; now only one-quarter. The results said Dean Alfred H. Keil of the M.I.T. School of Engineering, are tough new requirements on U.S. engineering — creativity, responsiveness to societal need, professionalism.

What is the chief difference between yesterday and tomorrow for chemical engineers? — a rhetorical question from J. Kenneth Jamieson, '31, former Chairman of Exxon Corp. His answer: plenty of unfinished business. □

Chemical Engineers: Growing Need and Growing Challenge

J. Kenneth Jamieson, '31

The following is a digest of remarks by J. Kenneth Jamieson, '31, Director and Former Chairman of Exxon Corp., at the dedication of the Ralph Landau Building at M.I.T. on March 5. Mr. Jamieson was Chairman of the National Sponsoring Committee for the building — a committee which tackled its fund-raising task ($14.6 million) with such enthusiasm and success that construction of the building was begun less than two years after the Committee started its work.

It will not come as a surprise that my main point today is: let us get on with the job of producing an expanded supply of top flight chemical engineers and the new technologies needed to solve our global problems. Both are urgently needed.

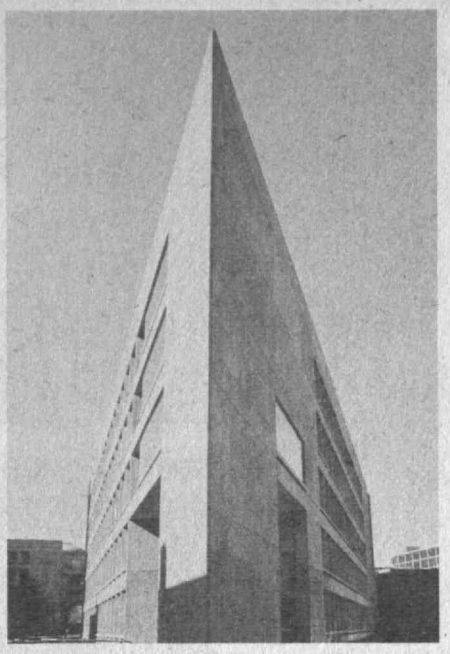
Industry properly looks to the leading centers of engineering education for the highly trained manpower and womanpower to tackle today's technology and to generate the basic research needed for tomorrow. We must look to the great research universities to produce the men and women who are able to deal with the full range of technological effort — from its smallest, intricate detail to its largest purpose. The chief difference between yesterday and tomorrow is that the scale of things will make individual rewards for success harder to recognize, the assessment of success more complex and multidimensional, and the penalty for failure much higher — for the individual as well as for mankind.

Chemical engineers with a firm grounding in the principles underlying advanced technology and with a capacity for leadership are sorely needed. There is plenty of unfinished business and in many areas not much time left to find new solutions to the tough problems of balancing theory and practice.

What does the economy tell us about the demand for chemical engineers? Currently we are on a rising curve of economic expansion. This means a rising trend of business investment in plant, equipment, and inventories; it means more engineers to plan, design, develop and build production capacity, and it also means renewed efforts to bring new products and processes on stream, despite the regulatory, environmental, and political obstructions which must be hurdled.

Let me illustrate by reference to the industry with which I am most familiar — the energy industry. The United States — indeed, the entire world — has become highly dependent upon oil and natural gas as sources of energy. Until the current decade these have been relatively low in cost and in abundant supply. Growth rates in demand were dramatic, averaging seven to eight per cent per year worldwide.

However, danger signs were visible. Production of oil and natural gas in the United States reached a peak in 1971. Even worldwide, new resources were not being discovered at the rate at which they were being consumed, so that in a sense we were living off past discoveries. Then, with the mid-East war of October, 1973, we were suddenly confronted with politically-created shortages of oil as a result of embargoes and massive price increases imposed by the Organization of Petroleum Exporting Countries. Suddenly the American public became conscious of a product which had heretofore been taken for granted because its supply seemed to be unlimited and its price low. The embargoes were lifted and



The $14.5 million Ralph Landau Building has an unconventional, triangular shape and strikingly attractive details. It is the first building built in M.I.T.'s recent history with funds from individual and corporate donors only. J. Kenneth Jamieson, '31, Director and Former Chairman of Exxon Corp., headed the Sponsoring Committee for the Building, and at the dedication luncheon he received a token of the Institute's appreciation — a Paul Revere bowl — from Howard W. Johnson, Chairman of the Corporation (left in the photo at the left). (Photos: Calvin Campbell and Roger N. Goldstein, '76)

supplies returned to normal in a relatively short time, but prices have since pushed even higher by the O.P.E.C. cartel.

What has happened since we began to realize that the U.S. is no longer independent in energy supplies, as it had been for so many years? First of all, there has been created the greatest crop of non-qualified energy experts the country has ever seen, and most of them are domiciled in Washington. As a result we have been flooded with panaceas and slogans: energy independence, keep prices down but expect people to conserve, break up the oil companies, stop obscene profits, end growth, ban nuclear power. But little or nothing has really been accomplished since 1973 toward a real solution to our energy problems; as a matter of fact, progress has been retrograde.

What of the future? We are an oil- and natural-gas-based economy. Domestic supplies are in decline. Prudhoe Bay in Alaska will come on stream in late 1977 but this will slow the decline only for a short time. Natural gas supplies will be in a continuous decline.

Supplemental energy resources must be obtained. We have to do everything we can to develop indigenous supplies — new oil and gas deposits yet undiscovered, known but unmined coal deposits, of which the U.S. has many, and nuclear power.

What does this mean in terms of chemical engineers and the industries in which they work? The energy industry will become much more complex and what I term plant-intensive. We must develop sophisticated methods for cleaning coal either before or after burning or both. We need to develop so-called synthetic fuels, and this will require a whole new generation of new types of chemical engineering processes. A large part of the petrochemical industry will probably have to shift from natural gas to alternate feed stocks. In spite of the current stalemate, nuclear fuel reprocessing and enrichment plants must be built. Conservation of energy will be a primary objective.

All of this can be translated into a high demand for engineers and scientists. The Ralph Landau Building is an example of private action taken at a crucial time to prepare for the future. It will produce handsome dividends for all of us for generations to come. The habit of success which has characterized the graduates of this Department is a bright and shining star in any crystal ball you examine for the future. We need such young people now as much or more than we ever have in the past. □

A Graceful New $14.6 Million Home for Chemical Engineering Is Named to Honor Ralph Landau

A new era opened for the Chemical Engineering Department on March 4 and 5 with the dedication of a new $14.6 million building and a symposium on "The Future of Chemical Engineering" that brought nearly 500 alumni and friends to the campus.

The dedication luncheon on March 5 was enlivened with the announcement that Ralph I. Landau, Sc.D. '41, was the major — until then anonymous — contributor to the campaign for the building; hence its designation as the Ralph Landau Building. It is the first building in the modern history of the Institute to be built entirely with funds from private individual and corporate donors (a total of over 1,300), and that fact obviously pleased Dr. Landau: "I have long expressed the belief," he said, "that the private sector should lend increased support to higher education. The new building made it possible for me to demonstrate that support in a highly effective and enthusiastic way."

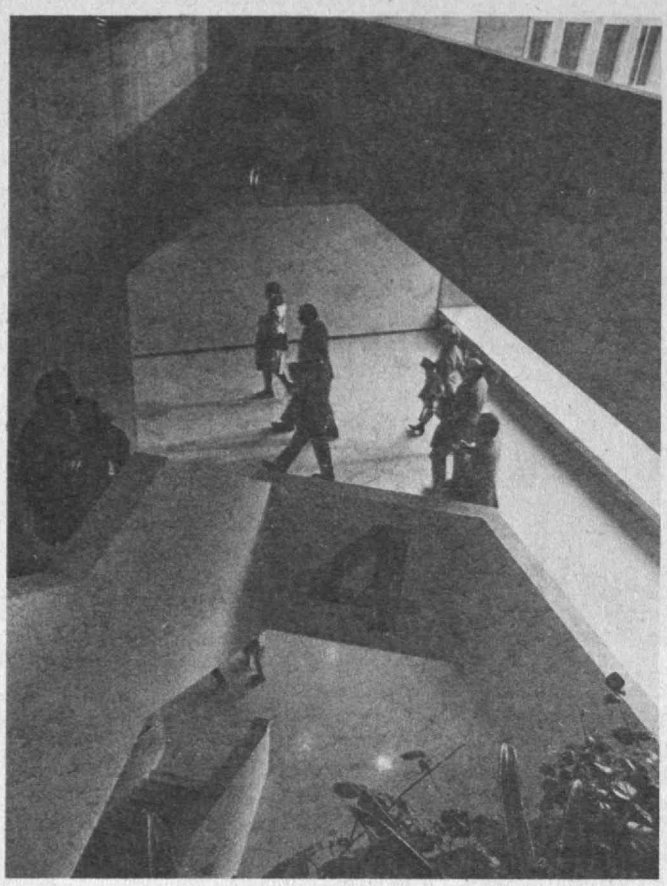
The new building, a striking triangular structure of poured concrete, was designed by I. M. Pei ('40) and Partners; it is a graceful and interesting addition to the East Campus, forming a link to Ames Street for the main academic buildings of the Institute. For the first time since World War II, the Department's teaching and research are housed in a single building under one roof.

Alumni Loyal to a "Golden Age"

Few departments at M.I.T. have contributed as much as this one to the development of the profession they serve, and few have had such a "golden age" as chemical engineering experienced in its first quarter century.

The first course in "chemical engineering" given anywhere in the U.S. was taught at M.I.T. in 1888 by Lewis M. Norton, '76, in the Department of Chemistry. By 1902 Professor William H. Walker had become head of a chemical engineering section in the Chemistry Department, and he was pioneering in the "problem method" of teaching the industrial applications of chemical knowledge. The late Warren K. Lewis, '05, was one of his students and returned to join the faculty in 1910.

By 1910 Professor Arthur D. Little, '85, had joined with Professor Walker to found the American Institute of Chemical Engineers, and in 1916 they organized the School of Chemical Engineering Practice; four years later chemical engineering became a separate department with Professor Lewis as its first head, and its faculty be-



As the building bearing his name was dedicated in March, Ralph I. Landau, Sc.D. '41, was identified as the principal donor — and honored with many expressions of the Institute's thanks. In the photograph above, Dr. Landau poses in front of the building with Mrs. Landau, their daughter Laurie, Howard W. Johnson (left), and President Jerome B. Wiesner (right). In the photograph at the left, the Institute's two principal officers stand with Paul M. Cook, '47, Chairman of the Sponsoring Committee for the Edwin R. Gilliland Professorship. (Photos: Calvin Campbell and Roger N. Goldstein, '76)

came "a constellation of eminent professors who created chemical engineering as a profession and who have constituted over the years a faculty of great teachers, great engineers, and great researchers."

The quotation is from remarks by James R. Killian, Jr., '26, Honorary Chairman of the Corporation, at a memorial service which concluded the dedication of the Landau Building. "The contagious companionship of excellence" — a phrase from the late Allen Gregg — was used by Dr. Killian to characterize the experience of students and faculty in the Department. "Few educational entities that I know," Dr. Killian said, "have an alumni body so close and devoted to a department as the alumni of chemical engineering."

Raymond F. Baddour, Sc.D. '51, Head of the Department of since 1969, said the same thing at the dedication luncheon. He has been "deeply touched," he said, "by the warmth, enthusiasm, and devotion of the alumni. As a group they stand out as an absolutely important and irreplaceable influence."

(It was announced at the luncheon that Professor Baddour has asked to step down as Head of the Department at the end of the current academic year, and a successor is now being sought.)

There are nearly 6,000 alumni of the Department. Though most of them have gone into industry, over 10 per cent of the nation's chemical engineering teachers have held one or more degrees from the Department. Of those who have made their careers in industry, a remarkable 10 per cent have become senior officers guiding the nation's largest companies or inspiring new enterprises which have grown to significant success.

A "Prescient Action" on Fuels Research

The Landau Building contains about 130,000 gross square feet of space, divided between laboratories, classrooms, and offices on seven floors — five above ground and two below. A large lecture hall on the first floor is named in honor of Professor Edwin R. Gilliland, Sc.D. '33, who headed the Department from 1961 to 1969; it is a gift of the Deering Milliken Foundation. A large student lounge on the second floor is named to commemorate Professor Walker.

A major gift from the Pew Memorial Trust made possible incorporating the Fuels Research Laboratory in the basement of the new building; that gift was "a truly prescient action for its time" many months before the onset of the "energy crisis," said Howard W. Johnson, Chairman of the Corporation, at the dedication luncheon. □

Ralph I. Landau: Prescriptions for the "Trilemma" of Chemical Engineering

"A new giant" has joined the ranks of those who have been "major benefactors of our society through M.I.T.," said Howard W. Johnson, Chairman of the Corporation, at the dedication luncheon for the Institute's new chemical engineering building on March 5. He was introducing Ralph I. Landau, Sc.D. '41, Chairman and Chief Executive Officer of Halcon International, Inc. — "an outstanding engineer and industrial leader, . . . a champion of engineering education, . . . a major force behind all our efforts to bring the new chemical engineering building on stream at M.I.T."

Dr. Landau was identified at the luncheon as the donor — previously anonymous — of $7 million toward the $14.6 million building fund.

"As a leader of the modern chemical process industry," said Mr. Johnson, "Dr. Landau provides for us a superlative example of high accomplishment. He has achieved uncommon success not only in visualizing a whole new set of processes and products; but also in bringing together the capital, technical expertise, and management and marketing competence to make possible a wholly new business."

For five years after completing his M.I.T. degree, Dr. Landau was with M. W. Kellog Co., finally as head of the Chemical Department of its subsidiary Kellex Corp. In 1946 Dr. Landau was a principal in founding Scientific Design Co., Inc., a process development and engineering construction firm which he served for several years as Executive Vice President. When Scientific Design became part of Halcon International in 1963, Dr. Landau became President of Halcon. The two firms under his leadership have engineered more than 200 plants and have licensed their technology to more than 100 international companies.

That technology represents a number of radically new developments, including the Mid-Century Process for oxidizing xylenes, a key process technique in providing most of the world's basic raw material for polyester fibers; and an oxidation process for propylene oxide. Dr. Landau himself owns 47 major patents in these fields.

An Unstable Three-Legged Stool

Why Dr. Landau's intense personal commitment to chemical engineering education, and his faith in M.I.T.?

Dr. Landau describes chemical engineering education as one arm of a "trilemma," caught between the needs of industry and the support of government. The "trilemma" is this:

Research funded by government is the principal source of ongoing support for faculty and graduate students in chemical engineering. Priorities conceived by the government thus dictate the subject and focus of both research and advanced teaching in the field, and the government's interests come to "dominate the attention of most faculties."

But industry's priorities are not necessarily those of the government, and so it is that university teaching and research become less and less relevant to the needs of industry. Dr. Landau's sympathies are with the Editor of *The Economist* who early this year warned British universities that they should "hold no illusions: For the most part, industry gets along well enough without your research."

The universities are in the middle, conscious of industry's need for broadly trained chemical engineers suitable for employment in all kinds of jobs but drawn by government support into training ever-more-specialized experts — biomedical engineers, enzyme engineers, polymer engineers.

The situation, said Dr. Landau at the symposium on the future of chemical engineering on March 4, is "a basic conflict of interest between the university's needs and the demands of industry on the product — graduates — of the process."

The "trilemma" comes to bear on M.I.T. in a very special way, he thinks. The private sector — because government would not do so — has made gifts of $14.6 million for a chemical engineering building; but the money required to take advantage of that new facility will come largely from government-sponsored research, and industry will be expected to take "an overhwelming proportion" of the graduates. It is a "three-legged stool," he said; "and — contrary to simple geometry — it may be a prescription for instability, especially if one leg is cut off!"

University-Industry Cooperation

One of Dr. Landau's prescriptions for resolving today's three-way contention is closer industry-university cooperation. For chemical engineering at M.I.T., for example, he proposes:

— Additional commitment by industry (his own firm is ready, he said) to cooperative programs in chemical engineering practice, including both a wider variety of industrial opportunities and more financial support.

— More chances for industrial people to participate in academic teaching as visiting professors and lecturers. (Dr. Landau's own firm sponsors a fellowship program in several institutions for just this purpose.)

— More curricular stress on industrial problems, and more curricula providing some combination of work in chemical engineering and management. For M.I.T., he is a strong partisan of an embryonic plan for a joint doctorate in engineering and management.

"Moral Philosophy" and an "Institute of Freedom"

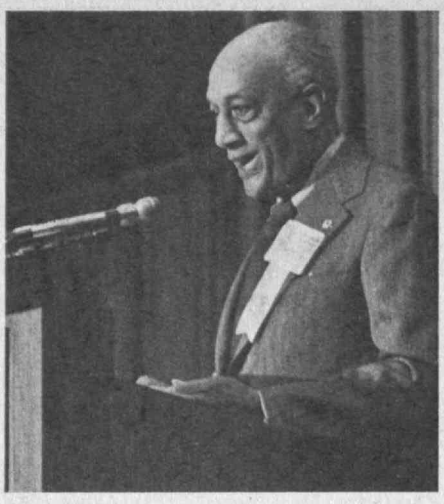
In his address at the dedication of the building which now bears his name at M.I.T. Dr. Landau went beyond these pragmatic proposals to suggest a new "moral philosophy" in university curricula. What he seeks, said Dr. Landau, is an integration of "the political, the ethical, the scientific, the technological, the economic, the rational elements of our free society" into a "synthesized moral philosophy" tied firmly to the realities of the modern world.

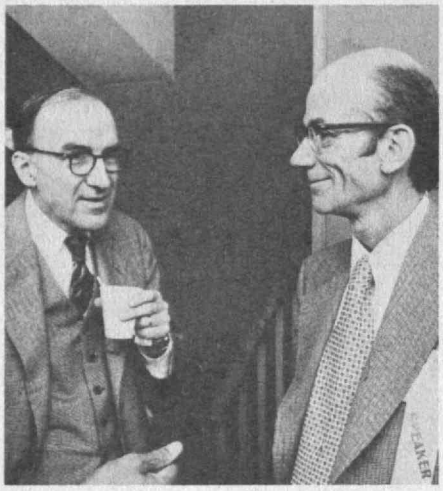
Dr. Landau's purpose, he says, is to reveal for what it is the "very dangerous nonsense" being generated at some institutions of higher education in the name of tax reform, wage and price controls, and "guarantees of equal results for all."

The task of developing this new "moral philosophy" is especially appropriate to M.I.T.: "No other university in America, in my opinion, could perform such a role in a way comparable to M.I.T., which is so strong in so many [critical] areas and in the interdisciplinary search for deeper and more complex knowledge."

The $14.6 million from private and industrial sources for M.I.T.'s new chemical engineering building would have been impossible without a system in which successful entrepreneurship is recognized by financial profit — an example of the realities which Dr. Landau wants more firmly incorporated into the American ethic and the thinking and teaching of American universities. He has confidence in M.I.T. on this point: "We have indeed always believed in excellence, in merit, in rewards for it, and in incentives to create it. We believe the same in industry. It's what makes our great economy flourish so much better than any other."

Dr. Landau proposed the establishment at M.I.T. of "an institute of freedom — a world center for the synthesis of philosophy and technology . . . devoted to examination of freedom from every viewpoint and to the development of policies for the preservation and strengthening of freedom rooted in the hard, practical approach for which M.I.T. is so famous." — *J.M.*





Highlights of the chemical engineering convocation included addresses by Henry A. Hill, Ph.D.'42, President-Elect of the American Chemical Society (top) and Edward W. Merrill, Sc.D.'47, Carbon P. Dubbs Professor of Chemical Engineering (shown center with John C. Haas, S.M.'42, who was Chairman of the Convocation.) (Photos: Calvin Campbell and Roger N. Goldstein, '76)

Tickets to Hell for Evils of Engineering

During his career as a graduate student in biochemistry at M.I.T., Henry A. Hill, Ph.D. '42, took only one course in chemical engineering. But now it's clear to him that "the gallons and tons that go into commerce bring home the money," not the nanograms or milligrams of the scientific laboratory. So sometimes, even as President-Elect of the American Chemical Society, Dr. Hill's advice to unemployed chemists is: "Learn a little chemical engineering. The demand is greater and steadier."

Dr. Hill also had a message for chemical engineers at the M.I.T. symposium on March 4: let the good works of the first century of chemical engineering live on through the ages, but "give some of the evil a one-way ticket to hell."

Bribing With the Best of Them

Among the works to be preserved: the pharmaceuticals and antibiotics that conquered the infectious and deficiency diseases. ". . . Polio, tuberculosis, diphtheria, syphilis, scurvy, ricketts, and pernicious anemia should not return. Nor should torch sweaters, cowboy chaps, and flammable children's sleepwear.

"There is also another category of good," said Dr. Hill, "that has outlived its usefulness — eldrin, dieldrin, DDT, PCB, Red Number Two, DES, perhaps even water chlorination and nitrite food preservation."

Another evil:

"Just recently the media have been full of multinational corporations and bribes, and I read that one of the company presidents was a chemical engineer. I do not know whether we should take pride in the fact that chemical engineers learn how to bribe with the best of them. Bribing is another one of the evils of the past century which I would like to see take the one-way trip to hell."

Learning to Reject Moral Pollution

Dr. Hill wants chemical engineers to take some responsibility for today's "energy crisis" too; after all, a good many of the engineering accomplishments of their first century — thermal cracking, catalytic cracking, hydroforming, tetraethyl lead — helped us become over-dependent on petroleum, he said.

So he hopes that the Chemical Engineering Department at M.I.T. will build into its future curricula an effective study of ethics. His goal: "We train our students to meet and deal with fellow men on equal terms; and just as readily as we would reject the pollution of the air, we would reject moral pollution; and just as we would not falsify the technical result, we should not falsify the political or business result."

And some technology assessment seemed also to be in Dr. Hill's prescription, so that chemical engineers of the next century would be working on the real problems of that century and not creating new problems for the next. □

Two Professorships in One Day to Honor Dow and Gilliland

It has never happened before: two new professorships in a single department fully funded and announced in a single day. But that opportunity came to Howard W. Johnson, Chairman of the Corporation, and President Jerome B. Wiesner on March 4 during the chemical engineering symposium marking the dedication of the Ralph Landau Building.

The Willard Henry Dow Professorship in Chemical Engineering is the gift of Herbert H. Dow, '52, and Mrs. Dow in honor of Mr. Dow's late father.

The Edwin R. Gilliland Professorship in Chemical Engineering was the three-month project of a national sponsoring committee of alumni headed by Paul M. Cook, '47, President of Raychem Corp. In that short time a total of $950,000 had been contributed, Mr. Cook reported at noon on March 4, and the $1 million fund was completed by that evening.

The Gilliland Professorship honors the fifth head of the Department who was a member of its faculty for 40 years after receiving his Sc.D. degree from the Institute in 1933. He was "a giant in our profession, a superb engineer, a brilliant teacher, and a fine human being," said Mr. Cook, and he reported countless spontaneous expressions of respect and affection from alumni who contributed to the Professorship fund.

Willard H. Dow, who died in 1949, was President and General Manager of the Dow Chemical Co. from 1930 and Chairman of its Board from 1941. Dr. Wiesner called the gift an "an extraordinary act of generosity"; Herbert Dow, he said, "has had a long and close personal association with many aspects of M.I.T." dating almost from his graduation from the Institute's course in general engineering. □

Energy: "The First Time I've Ever Confronted Anything Like This," says Seamans; $1.5 Million to M.I.T.

The nation's number-one energy man says energy is the nation's number-one problem — a "very serious" matter, Robert C. Seamans, Jr., Sc.D. '51, Administrator of the Energy Research and Development Administration, told the M.I.T. Club of Boston late last winter. "We have to do something very dramatic in this country or be in very serious trouble," he said.

Two examples:

— "We are dependent on others for what is absolutely essential to our lifestyle, industry, and security," and he finds that an "uneasy" position.

— Between 75 and 80 per cent of our energy comes from gas and oil — the least plentiful of our resources.

Some people assume that a nation that can send men to the moon will solve its energy problems, but Dr. Seamans insists that energy is different. The Apollo moon-landing program was amenable to central direction and management; but energy is a socio-economic problem as well as a series of technological problems — a factor in almost every aspect of American life, a problem with countless dimensions.

"It's the first time I've ever confronted anything like this," Dr. Seamans said — and he thinks it's a similarly new problem for the nation.

Just What the Energy Laboratory Needed

The multi-dimensional nature of the energy problem was E.R.D.A.'s motivation for support of a new, coordinated, multidisciplinary research program in the M.I.T. Energy Laboratory, Dr. Seamans told the M.I.T. Club of Boston; and he announced a three-year agreement under which $1.5 million became available immediately for use before July 1, 1976, by the Laboratory. It is the first institutional award of its type made by E.R.D.A.

Most E.R.D.A. research grants are on a specific project-by-project basis. The point of the institutional grant, said Dr. Seamans, is to provide a "flexible mechanism" for coordinated efforts that span several projects and disciplines, a response to the special character of energy problems themselves.

E.R.D.A.'s support will be used by the M.I.T. Energy Laboratory for multidisciplinary research by faculty and students in eight areas: fossil energy, nuclear energy, solar and advanced energy systems, conservation, environmental technology and planning, research strategies and policy, international studies, and exploratory research. Faculty and students from throughout the Institute will participate.

The E.R.D.A. grant is just what David C. White, Director of the Energy Laboratory, has needed to realize the Institute's potential for contributions to understanding and resolving energy problems. He speaks of the need to study "complex trade-offs" — both economic and technological — in using existing energy resources and developing new ones, and he says such analyses must draw on "a mix of disciplines in physical science and engineering, economics and management, environment and health, and law and society."

President Jerome B. Wiesner hailed the E.R.D.A. program as a "most significant step forward, both for the development of the M.I.T. Energy Laboratory and in the creation of a more effective national energy program." He called it a much-needed new kind of relationship between government and university research in the energy field and "a powerful thrust to get on with the task of solving the energy problem."

As Director of the Energy Laboratory, Professor White will coordinate the E.R.D.A.-M.I.T. institutional agreement in Cambridge; there will be technical evaluation by E.R.D.A. on an on-going basis and semi-annual senior level reviews of progress and plans. □

When Robert C. Seamans, Jr., Sc.D. '51, right, Director of the Energy Research and Development Administration, came to speak before the M.I.T. Club of Boston late this winter, David C. White, Director of the M.I.T. Energy Laboratory, joined him to celebrate a new partnership between E.R.D.A. and M.I.T.: a three-year institutional grant from E.R.D.A. to support a coordinated, multidisciplinary energy research program at M.I.T. Some $1.5 million was authorized for work at M.I.T. in the current fiscal year, Dr. Seamans said.

M.I.T. Joins A.T.&T. to Celebrate 100 Years of Telephones; a New Era Ahead?

When is an invention invented?

Throughout the first years of the 1870s, while he was teaching and working in Boston — he was a familiar figure at M.I.T. but was never a member of the faculty — Alexander Graham Bell had in his mind the possibility of communications over a single wire which would be far more efficient than the telegraph.

Mr. Bell gave several lectures at M.I.T., and after the first one he rejoiced that it had "placed me in a new position in Boston. It has brought me into contact with the scientific minds of the city," he wrote. Later, when Mr. Bell was among M.I.T.'s guests at the dedication of the Institute's new Cambridge campus in 1916, he credited M.I.T. with being "the first scientific institution to give help to the invention of the telephone."

Mr. Bell's key breakthrough came on June 2, 1875, when by accident he and his assistant, Thomas A. Watson, discovered that a moving magnet could be made to vary a current of electricity in a wire; "the speaking telephone was born at that moment" of discovery, Mr. Watson later wrote. By February 14, 1876, Mr. Bell applied for his telephone patent, which was granted on March 3. Continuing his experiments, Mr. Bell on March 10, 1876, had the misfortune to spill some acid on himself in his rooming-house laboratory in the Back Bay, and he used the experimental telephone to ask Mr. Watson to come to his aid from a nearby room:

"Mr. Watson. Come here. I want you."

It was the first transmission of an intelligible message by a primitive pilot model of today's household telephone.

March 10, 1976, was the date chosen by the Bell System, M.I.T., and the U.S. Postal Service to celebrate the centennial of Mr. Bell's momentous invention. There were a major Convocation on Communications at M.I.T., ceremonies for the first-day sale of a U.S. Postal Service commemorative stamp in the du Pont Gymnasium at lunch on March 10, and a formal telephone centennial banquet that evening in Boston at which young descendents of Mr. Bell and Mr. Watson reenacted the first telephone call, first over replicas of the original instruments and then over an optical-fiber communication link.

How Research Spawns Societal Benefits

Convocation sessions made it clear that the past is prologue to a very different future in the field of communications. Major sessions were devoted to language — the tool of communication — to the future impact of computers and information processing, and to the social impact of the telephone; all these are summarized elsewhere in this issue (*see pages 24-25*). More than 1,000 specialists from throughout the country attended.

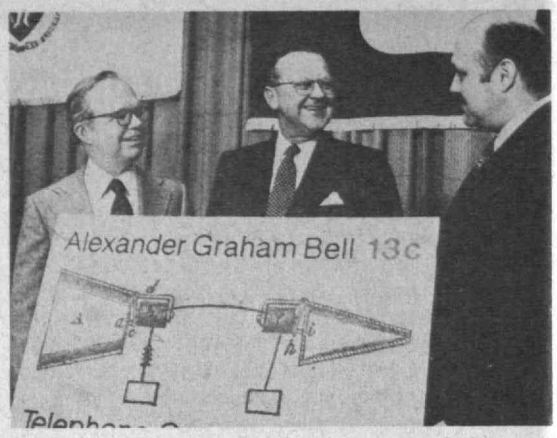
Arthur C. Clarke, a distinguished writer of science and science fiction, concluded the Convocation with an address on "Communications in the Second Century of the Telephone," which also appears elsewhere in this issue (*see pages 32-41*).

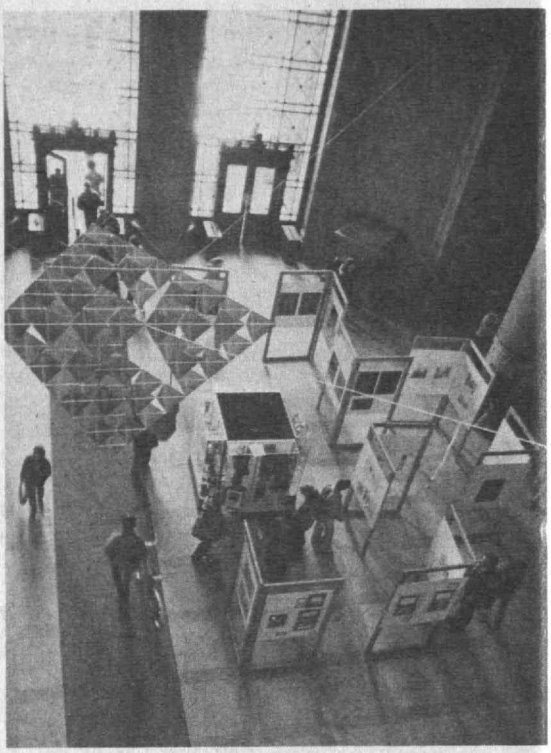
And John D. deButts, Chairman of the Board of A.T.&T., emphasized the relevance of the futuristic theme: "The history of the telephone is a history of constant questing toward a better way," he said, "a record of continuous innovation unmatched by any other industry."

President Jerome B. Wiesner chose the opening session of the Convocation to stress the value of basic research in the course of such an ongoing technological adventure. The telephone and the communications system it spawned, he said, are "a vivid reminder, much needed today, of the vital role of basic research in human development.

"The history of telephone-based communication is replete with examples of how knowledge, accumulated for one purpose, can enrich countless, apparently unrelated fields, and of how a determined and continuing research and development effort spawns new devices, industries, and societal benefits."

To some observers, the ceremonies for first-day sale of the new 13-cent telephone commemorative, in which U.S. Postal Service and A.T.&.T. representatives were principals, seemed prophetic of the telephone's second centennial, when paper may be largely supplanted by electronics in communications of all kinds. Frederick R. Kappel, former Chairman of A.T.&T. who is now a member of the Postal Service Board of Directors, was present; and Postmaster General Benjamin F. Bailar emphasized the Postal Service's increasing commitment to new technology. □





"When a sound is uttered in the cone, the membrane a is set in vibration, the armature c is forced to partake of the motion, and thus electrical vibrations are created upon the circuit. . . ." This is the description in Alexander Graham Bell's telephone patent, and from his drawing came the design of the U.S. Postal Service's commemorative for the centennial of the telephone. First sale of the stamp occurred in Boston on March 10, and "first-day" ceremonies were a feature of a luncheon at M.I.T. that day, during a major Convocation on Communications. In the picture, behind a reproduction of the stamp, are Howard W. Johnson, Chairman of the Corporation; John D. deButts, Chairman of the Board of the A.T.&T.; and Benjamin F. Bailar, Postmaster General. To complement the Convocation, the lobby of the Rogers Building was filled with an exhibit of telephone technology — ancient and modern. (Photos: Calvin Campbell and Roger N. Goldstein, '76)

An historic reunion of Course XVI leaders. Four old friends met when Robert C. Seamans, Jr., Sc.D. '51, (left), Director of the Energy Research and Development Administration, spoke to the M.I.T. Club of Boston last winter (see page 79). With him (left to right) are Jerome C. Hunsaker, '12, the founding Head of the Department of Aeronautical Engineering; Charles S. Draper, '26, former Head who founded the Laboratory which now bears his name; and Rene H. Miller, Head of today's Department of Aeronautics and Astronautics.

Three seniors are holding checks from the Association of M.I.T. Alumnae — the Alumnae Senior Academic Awards given each year by A.M.I.T.A. on the basis of academic excellence. The winners: (left to right) Laurel A. Fisher, '76, who will graduate in nutrition; Ellen Scotti, '76, whose major is mechanical engineering; and Koon G. Neoh, '76, a senior in chemical engineering (from Penang, Malaysia). The awards were presented by A.M.I.T.A.'s Awards Chairman, Cho Kyun Rha, Associate Professor of Food Process Engineering in the Department of Nutrition and Food Science.

Early Spring Under the Domes

They "Just Aren't Interested"
A universal complaint from student members of faculty committees such as discipline, curricula, educational policy, and student environment: the rest of the students "just aren't interested." "Most students don't come up and say anything to you — only when they disagree with everything," says David A. Hoika, '77. "How can you find out what the student view is?" complains Victor Franckiewicz, '76, of the Discipline Committee.

But Glenn R. Brownstein, '77, Editor-in-Chief of *The Tech,* takes a somewhat different view: "In a school like M.I.T., where free time is at a premium, it's perhaps unfair to require students to join committees to give feedback, especially when many committees handle a so-called 'hot issue' every four or five years at most. This isn't apathy, but merely protecting our $6,000-plus investment each year."

Registration: Shorter Lines, Better Glue
Registration-Day lines used to stretch all the way from the Armory to Bexley Hall. This spring physical education registration was delayed until a second day, cutting line waits to a maximum half-hour. Winston E. Flynn, Assistant Registrar, thought the experiment was promising, although "we don't have the right answer yet."

But the embarrassing problem of adhesive-backed validation stickers that wouldn't stick to identification cards seemed to be solved; "the glue is better this term," said Warren D. Wells, '48, Registrar.

The Great Budweiser Scandal
Telegram from Anheuser-Busch to Mark T. Suchon, '76, Chairman of the Interfraternity Conference: will M.I.T. enter a team (all expenses paid) in the 1976 Fourth Annual Great Budweiser Canoe Race? (Teams of 30 students, mixed men and women, paddle for 72 hours through the Busch Gardens in Van Nuys, Calif.) A minor campus scandal ensued when the first try yielded a team heavily skewed toward the fraternities and including women from Simmons, Boston, and Wheelock Colleges. Another try, and 17 M.I.T. men and 13 M.I.T. co-eds were on the way to California. Surprise: they brought home the second-place trophy in the race, generous comments on spirit and prowess, and "memories of Disneyland and the California beaches," said *The Tech.*

How to Squeeze Them In?
More students next fall means overcrowding in the Institute Houses — 20 over the nominal capacity in MacGregor House, 40 in Burton-Conner, 40 in East Campus, ten in McCormick, eight in Senior House, ten in Baker, five in Bexley, 20 in New House, according to Kenneth C. Browning, '66, Associate Dean, after negotiations with dormitory representatives. To help soften the blow of over-crowding, rent reductions and new furnishings to make crowded rooms look and work better were mentioned by Dean Browning. He "strongly endorses" the principle of "not forcibly impacting crowding on upperclassmen."

A New Fraternity?
Partly stimulated by the housing crunch, two moves are reported afoot to form another men's living group. Alpha Delta Phi, which Dean Browning describes as "a low-key national fraternity," is interested in a chapter at M.I.T., and so is a group of men on the campus. If the latter "ever get together with Alpha Delta Phi, this thing may take off," Dean Browning told *The Tech* early in the spring.

Up With Bexley
Bexley Hall will be "rehabilitated" this summer, at a cost of some $350,000: new plumbing, heating, and electrical systems, remodeled kitchens and bathrooms, a new roof, new radiators, some replastering and lots of new paint.

Taiwan: Issue or Non-Issue?
Fifteen trainees from Chung Shan Institute of Science and Technology of the National Taiwan University are at the midpoint of a training program in the Center for Advanced Engineering Study on high-technology industry, taking as their chief example the kind of complex electro-mechanical technology in inertial navigation systems. Pressed by uneasy students and faculty, M.I.T. admitted that inertial principles may figure in some missile guidance systems; but "the students from Taiwan are not being trained in the development of missile guidance systems," said an official News Office statement. The purpose of the program is "to provide a group of new entrepreneurs who can help the National Taiwan University develop high-technology industries within Taiwan."

Esmerelda or Neville?
Paul J. Giordano is a graduate student in chemistry, and he and his wife are tutors in New House. Mrs. Giordano will have a baby in July, and when New House residents heard the good news they set up a contest to name the new arrival. Result: posters throughout the campus one day early this spring on pink and blue paper: "Name Her Esmerelda" and "Name Him Neville."

No Smoking at No Cost
A recent Cambridge city ordinance prohibits smoking except in a specially designated section of any "classroom, lecture hall, theater, opera house, concert hall, or library." Early this spring Professor David Gordon

Wilson and colleagues in "M.I.T. Action on Smoking and Health" (A.S.H.) petitioned the faculty to enforce the ban at the Institute. The faculty approved, a student referendum voted yes by a 5-to-1 margin, and the Registrar's Office was reported ready to put up "no smoking" signs "within a few days." A.S.H. volunteered to supply the signs at no cost to M.I.T.

Writing with Minorities

Two of the nation's largest black-owned insurance companies — North Carolina Mutual and Supreme Life of America — will now join John Hancock in writing M.I.T.'s group life insurance coverage. Paul E. Gray, '54, Chancellor, says it's a "significant commitment" to help minority companies; each new company will take on 5 per cent of the coverage, sharing revenue and risk, with administrative and contractual responsibilities continuing with John Hancock.

From MAC to LCS

Project MAC (*M*achine-*A*ided *C*ognition), in which were developed two pioneering time-sharing systems for computers — CTSS and MULTICS — has a new name as of February: the Laboratory for Computer Science. The change is to "reflect more accurately" the Laboratory's mission of general research in computer science and engineering. Today's L.C.S. has 270 members and associates — 30 faculty, 80 professional staff, and 130 students — organized in 13 research groups. Three principal areas of research: to make computer programs more intelligent, to improve the accessibility and cost-effectiveness of computing systems, and to extend communication and computation theory. L.C.S. Director is Michael L. Dertouzos, Ph.D. '64, Professor of Computer Science and Electrical Engineering.

Films and Tapes

A 100-page catalog of 500 instructional films and videotapes for teaching science, engineering, mathematics, and management has been assembled and is now available from the Center for Advanced Engineering Study. It includes many C.A.E.S. materials heretofore available only in complete course form, now being offered individually. For a copy, write Russell Seidel, C.A.E.S., Room 9-230, M.I.T.

Phonathon Success

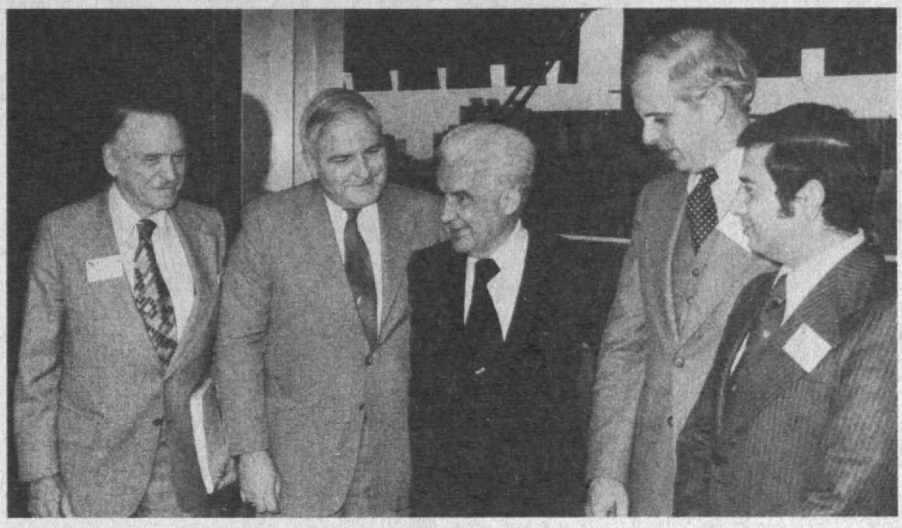
Seventy-four students worked a total of 247 volunteer hours for the Massachusetts Easter Seal Society in Boston late in February. The occasion was a state-wide phonathon to seek renewed financial support from 8,000 prior donors. The students were recruited as a result of a single call from Robert A. Nadeau of the Easter Seal Society to the Interfraternity Conference; Mr. Nadeau says the students "saved the day and made the phonathon an overwhelming success."

The Lighter Side of the Arts

The audience was to be in swimsuits in the Alumni Pool for "Under Aquarius," a production of Joan Brigham and Stan Van der Beek, Fellows at the M.I.T. Center for Advanced Visual Studies. A submerged theater of images would produce an "envelope environment . . . of light refractions, ghostly video images, and mysterious vapor configurations," said the news release. . . . A concert of electronic and computer music, arranged for the 11th National Conference of the American Society of University Composers, included the premiere of "Synapse for Viola and Computer" by Professor Barry L. Vercoe with Professor Marcus Thompson as soloist. The concert marked the official opening of the M.I.T. Experimental Music Studio; Peter C. Coffee, '79, said in *The Tech* that Professor Vercoe's work is "a successful blend of old and new . . . [emphasizing] the strengths, both mutual and distinct, of the viola vs. the new Institute computer [which also printed the score]." . . . A capacity crowd of enthusiasts greeted Gene Roddenberry, creator of Star Trek, for a Kresge Auditorium lecture. First came a "blooper clip," wrote Henry G. Fiorentini, '79, in *The Tech:* ". . . such unique shots as Captain Kirk walking into doors that didn't open, actors forgetting their lines or missing their cues . . ." Then an ovation for the announcement that a feature-length Star-Trek movie will move into production in the fall. □

How do we see? How do we move? How do we express emotion? How do we remember? Key questions in the search for understanding of the operation of the brain, said Hans-Lukas Teuber, Head of the Department of Psychology, at a dinner meeting of the M.I.T. Club of Northern California in Palo Alto last winter. One difficulty emerges as new technology is brought to bear on such problems: the inherent difficulty for scientists and engineers to work with the ambivalences of living organisms and, conversely, for biological scientists to submit to the exactness required in engineering. More than 90 alumni and guests were present. (Photo: Philip L. Molten, '55)

Management Science in Mexico City



Among principals in the M.I.T. Regional Conference in Mexico City in January: (left to right): Luis A. Ferre, '24, former President of the M.I.T. Alumni Association; Paul E. Gray, '54, Chancellor of M.I.T.; Manual Expinosa Yglesias, President of the Bancos de Comercio System (sponsor of the Conference); William F. Pounds, Dean of the Sloan School of Management; and Enrique Garcia Corona, S.M. '66, President of the M.I.T. Club of Mexico City. (Photo: Jesus Cruz R.)

You may think of Mexico as a "developing" country with only the beginnings of a modern industrial and financial system. You are wrong, and your error would have been clear had you attended the M.I.T. Regional Conference in Mexico City on January 30 and 31.

Three hundred of the country's industrial leaders listened with "positive interest" to presentations by Paul E. Gray, '54, Chancellor, and five members of the faculty of the Sloan School of Management, and they came away with "a new plan for the development of top executives in our country," said the English-language *Mexico City News*.

Here are excerpts from accounts by *News* reporters of the four principal management speakers' contributions:

Arnoldo C. Hax, Associate Professor of Management, "revealed little-known aspects in which logistics can help top executives in decision-making. . . . During a press conference he said that today decision-making is of increasing importance because of the factors, interests, and preoccupations of the community which are intimately linked with the company. 'The top executives of a company,' he said, 'have now a greater responsibility to act as elements of a team, as links between internal and external factors.' "

Donald R. Lessard, Assistant Professor of Management, dealt with the contrasting interests of stockholders and managers. His conclusion: ". . . with the exception of some few cases, the interests of the shareholders and their particular point of view should prevail in decision-making, even though the opinion of the management should also be taken into consideration."

Reporters were impressed by the scope and depth of the research reported by Edgar H. Schein, Professor of Organizational Psychology and Management — studies "spanning a period of 20 years. . . . In general terms, it could be said that Dr. Schein's talk will be very valuable in detecting, at an early age, someone who will become a capable general manager."

"A new golden age for the Mexican petroleum industry" was the prediction of Henry D. Jacoby, Professor of Management; "he called the present petroleum conditions in the nation 'a great situation for Mexico,' " said the *Mexico City News* reporter; it was "one of the most detailed reports ever given in Mexico in connection with the worldwide petroleum situation."

The "Human Aspect" of M.I.T.

The Mexican reporters also found revealing the reports of M.I.T. brought to the Regional Conference by Dr. Gray and William F. Pounds, Dean of the Sloan School. Dr. Gray "revealed the intimate relationship of M.I.T. with commerce, industry, and business in many countries of the world, . . ." And Dean Pounds impressed his audience by "unveiling a new facet of M.I.T. — its human aspect."

" 'M.I.T. worries,' Dean Pounds said, 'about human problems within society itself as much as it does about technological advancement. . . .' "

The Mexico City seminar was sponsored by the Bancos de Comercio System and held in its corporate headquarters in Mexico City. □

The Slide Rule's Reign Is Ended as the Coop Sells $1 Million Worth of Calculators

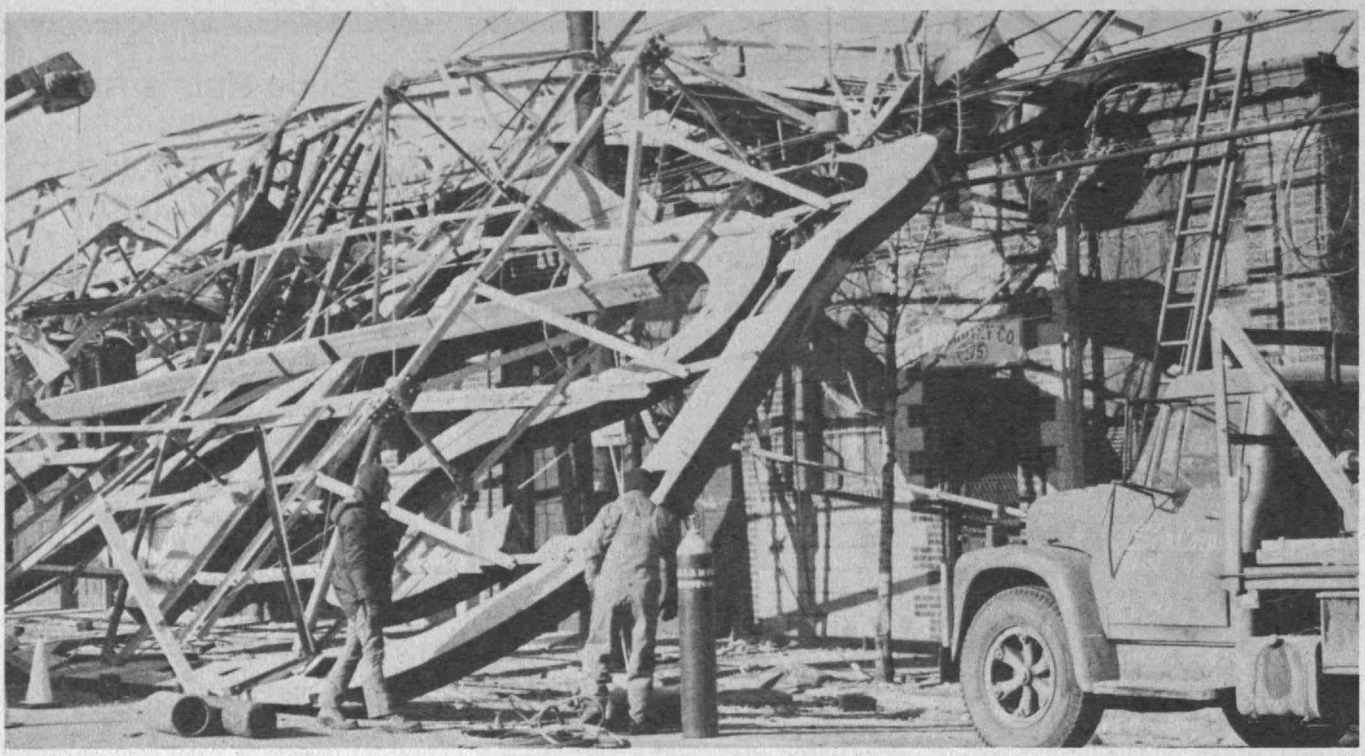
Michael J. Witham, '79, told the Associated Press he hasn't used his since before he finished high school. James D. Bruce, Sc.D. '64, Associate Dean of the School of Engineering, tells the *Boston Globe*, "It makes a good straight edge." And while this was happening, Charles MacDonald, buyer for the Harvard Cooperative Society, could point to $4,600 worth of merchandise on the way back to the factory because no one wanted to buy — even at half price.

Like the steam-drawn passenger train and the DC-3, the slide rule is suddenly an artifact of the past.

The mark of an M.I.T. student used to be a slide rule in a leather belt holster. Now it's a tiny calculator in a shirt pocket.

The Harvard Cooperative Society sold over $1 million in calculators in 1975; meanwhile, slide rule sales slipped to 1/15th of their former volume.

Does Dean Bruce mourn the change? Not really; a slide rule has only one advantage over a calculator, he told William B. Hamilton of the *Boston Globe:* a student has to be aware of the kind of answer he is looking for when he uses a slide rule. But with calculators "you don't have to worry about the decimal point. The answer doesn't have to make sense." □



Winds gusting up to 90 miles an hour early in February accomplished what generations of M.I.T. students could not: "They razed Cain's," said Tech Talk, *blowing over the neon "Cain's Mayonnaise" sign at 275 Vassar Street across from the West Campus. William Adams '33, Vice President of John E. Cain Co. of Ayer, Mass., called it a total loss. Would it be re-erected? No decision yet. (Photo: Calvin Campbell)*

An Urban Planner Visits China: Hard Work, Sacrifice, and Unity; Food, Light, and Bells

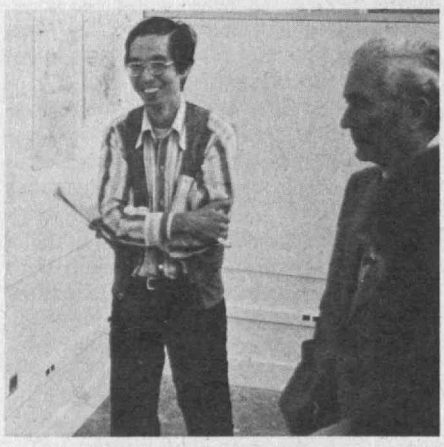
With funds provided (in part) by the M.I.T. Laboratory of Architecture and Planning, Tunney Lee, Associate Professor of Architecture and Urban Planning, returned to his native China in the summer of 1975 — partly to obtain curriculum material and continue research on planning in socialist countries. Here is the brief, enthusiastic account he provided for the Newsletter of the M.I.T. School of Architecture and Planning (December, 1975):

I traveled in the People's Republic of China (visiting Canton, my home village in Taishan, Wukan, and Peking) in July, 1975, for 24 days. What I saw was a developing country (per capita G.N.P. comparable to India's) that is struggling to become a classless society and succeeding to a great extent. China challenges the idea that competition and material incentives are necessary to motivate people to work and be creative. China distributes its scarce resources equitably and expects everybody to do his or her share of manual labor. There is an atmosphere of hard work, sacrifice, and unity. People feel that when their labor benefits society, they benefit themselves because they share fully and equitably in the society. The Chinese continue the experimentation on the way to becoming a modern industrial country.

Working Together to Harness Nature

The day starts in the cities at 6:30 a.m. Noisy with busses and trucks and the few automobiles (none privately owned) honking at the fearless bicyclists three or four abreast. Trees planted on every street with sidewalk space. Old alleys with electricity, running water, and communal toilets. Sidewalks lined with workshops started by housewives making paper boxes, assembling electric generators; recycling stations that will collect and pay for almost anything including broken glass, old shoes, and bones; day-care centers started by old grandmothers; health stations; variety stores and food stores and markets. The night scene is dark and quiet (without any sense of tension), people quietly strolling, bicycle bells tinkling, people clustered under street lights reading and talking.

Countryside impressions: Reforestation, the barren hills — deforested centuries ago — replanted with each tree in its carefully dug and watered hole. Small, old individually-owned plots combined to make larger collectively-owned fields. Swamps converted to rice paddies. Light green rice seedlings waiting to be transplanted. Rice being harvested. Three crops per year where there used to be two; two where there used to be one. Hydroelectric power from dams controlling rivers that used to flood. Electricity for lights, threshing, pumping. Irrigation channels. Aqueducts. People working together harnessing nature. No longer is "man's fate determined by heaven." Famine is a thing of the past. □



Back from China, which he found a nation "on the way to becoming a modern industrial country," Tunney Lee, Associate Professor of Architecture and Urban Planning, joins Emeritus Professor Lawrence B. Anderson, '30 (right), teaching Professor Anderson's design studio.

Foundry Is Alive and Well at M.I.T.

Artists, students, faculty and assorted tinkerers — everyone whose goal is to cast metal beats a path to Edwin H. Backman's door. And under his guidance they have produced everything from Tibetan chimes to a replica of a Civil War cannon.

Mr. Backman is foreman of the Solidification and Casting Group in the Department of Materials Science and Engineering, and in over 20 years at M.I.T. Mr. Backman has earned a reputation as a foundryman extraordinaire with students and faculty members in materials science, architecture, and other fields who come to him with designs originally modeled in wax, clay, sand or plastic for casting into metal.

Some recent student projects, completed in a workshop during last year's Independent Activities Period, include a demonic flying elephant cast in pewter, a large aluminum frog created by a Wellesley student, and an aluminum orchid that is three feet in diameter. Students have also produced a variety of mountain climbing equipment, piggy-banks, pewter mugs with M.I.T. insignia, and precision instruments such as gears and locks.

Mr. Backman particularly recalls one student who "sent away for government specifications on a certain type of Civil War cannon which he did a good job reproducing. Then he took the cannon home and tested it successfully in his back yard with a little gunpowder," he said with a shake of his head.

"Another student brought me a pair of Tibetan chimes he wanted to copy," Mr. Backman said. "Monks traditionally make the chimes and their precise metal composition and casting technique are a carefully kept secret." Mr. Backman did a careful analysis of the metal content of the chimes in order to duplicate the sound.

Mr. Backman has also executed sculptures for numerous artists, among them Gyorgy Kepes, Institute Professor Emeritus, and Theodore Roszak, who designed the spire and bell for the M.I.T. Chapel. Indeed, Mr. Backman was the foreman of the foundry crew that cast the bell in 1955.

Another major part of Mr. Backman's work has been in foundry research. Recently he was a member of the team that worked to perfect a process called "Rheocasting." This new process is a revolutionary method of making metal parts, including steel, by forming the parts when they are partly liquid and partly solid.

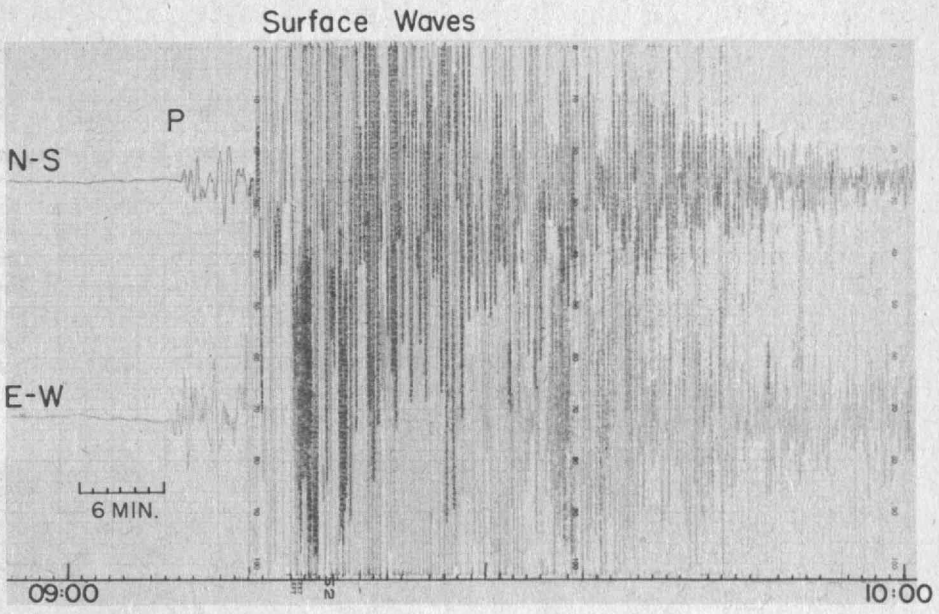
From 1957 to 1960, Mr. Backman worked with sculptor Alfred M. Duca to develop a method for using models of foam plastic for casting sculpture. They used polystyrene in a process called "foam vaporization," which faithfully reproduces large and small sculptures; it has now been widely adopted by sculptors in the U.S. and abroad. □

The Guatemala Earthquake Came Ten Years too Soon; "Meaningful Prediction" a Decade Away?

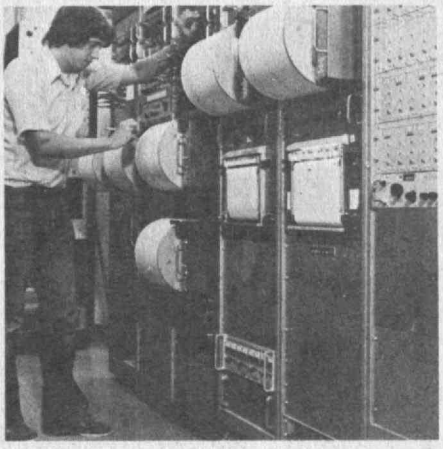
The first sign of a major earthquake in Guatemala arrived at M.I.T.'s George R. Wallace, Jr., Geophysical Observatory 6 minutes and 21 seconds after the event, which occurred at 04:08:04.6 E.S.T. on February 4; that was the wave (P, above) which traveled through the earth with highest velocity. Then came the surface waves which propagated more slowly but were so large that they saturated the Wallace Observatory's highly sensitive instruments. The upper trace shows the north-south component of ground motion, the lower the east-west motion.

Such seismic records help geophysicists determine the structure of the earth between the earthquake epicenter and the recording station and the mechanism of faulting at the earthquake center. In both respects, says Professor M. Nafi Toksöz, Director of the Wallace Observatory, they help geophysicists realize the elusive goal of earthquake prediction.

The damage wreaked by the Guatemala earthquake supports Professor Toksöz' contention that earthquake prediction has special significance for developing countries, where earthquake-resistant construction is non-existent; and he urges the need for a worldwide earthquake prediction network manned by "the world's leading technological nations." Predictions "better than 50 per cent accurate" are "well within reach in well-instrumented areas within the next ten years," says Professor Toksöz. □



Ground vibrations from the Guatemala earthquake of February 4, 1976 (04:08:04.6 Eastern Standard Time, 09:08:04.6 Universal Time) were recorded by the seismic sensors at M.I.T.'s George R. Wallace, Jr., Geophysical Observatory. The records (seismograms) of the north-south and east-west components of the ground motion are shown in the figure. The very first signal marked "P" is the wave which travels through the earth with the highest velocity. It arrived at the Wallace Observatory 6 minutes and 21 seconds after the earthquake. The distance between the earthquake epicenter and the Wallace Observatory at Westford, Mass., is 3,465 kilometers (2,151 miles). The larger amplitude waves are surface waves that propagate more slowly. Note that the earthquake was so large (magnitude) that it "saturated" these highly sensitive instruments.



Zacharias on Mathematics via Television: Show "the Total Orchestrated Power"

Jerrold R. Zacharias says he conceived "Infinity Factory" because children need an "intellectual machete" to cut their way out of everyday problems and everyday answers. He wants to give eight-to-eleven-year-olds a sense of self-confidence about mathematics — and, because many of the viewers come from black and Latino backgrounds, a feeling of ethnic pride.

"Infinity Factory" is a 30-minute mathematics program which premiered at the end of January on Channel 2 in Boston and during February in Los Angeles. The Education Development Center in Newton, Mass., which Dr. Zacharias founded to improve high school physics teaching, produced 65 30-minute programs with a $4-million grant from the National Science Foundation; the programs will be shown, at the rate of two each week, for the rest of the current school year.

It was in the 1950s that Professor Zacharias, who was then Professor of Physics at M.I.T. — he retired in 1970 to become Professor Emeritus — conceived of the Physical Science Study Committee, whose pedagogical revolution has today reached more than five million high school physics students. Ever since then, he's also had a theory that American television could be an ideal cure for what he calls "a peculiar American malady, 'mathophobia.' " "Infinity Factory" — for which Professor Zacharias is Senior Adviser — is to test that theory.

In a typical episode of "Infinity Factory," the local candy-store owner, Scoops, and his teen-aged helper, King of the Kids, listen sympathetically to a girl who has been excluded from the neighborhood boys' track team. The team captain is called in, and a graph is used to show him that the girl's running times are improving even faster than his — even though her time is now slower, she'll soon be able to beat him. A happy ending: the girl wins her argument and a place on the team.

"Infinity Factory's" format of animated cartoons, "math-in-the-street interviews," filmed documentaries, and basic arithmetic facts tries to change attitudes towards mathematics in five ways:

— End the vision of drills and multiplication tables as "threats."

— Show children how mathematics is used in real situations, and how they can use it.

— Present basic tools which children need in order to use mathematics.

— Help children to think analytically.

— Instill confidence about children's heritages to help them make their points more convincingly.

"Arithmetic relates to mathematics as scales relate to music," says Professor Zacharias. "We hear the beauty of music all the time, but we forget that you have to practice before you can play a concert. In the same way, most don't recognize the total orchestrated power of mathematics. Most of us don't even recognize that the power exists." □

"Does anyone know what 'estimation' is?" — a question for discussion among the multi-ethnic cast of "The Brownstone," a mini-series within a new mathematics series called "Infinity Factory." Professor Jerrold R. Zacharias, the principal founder of the Physical Science Study Committee whose physics curriculum has been used by five million high school students, wants the new television series to cure what he calls "mathophobia" in eight-to-eleven-year-olds, encouraging them to use mathematics and to think analytically. Sixty-five episodes will be shown on educational television in Boston and Los Angeles this spring.

Biohazards Committee

Scientists at M.I.T. who confront the dilemma of generic and physiological research that may have both positive and negative values for man now have a source of advice and counsel.

The problem arises out of the widespread use of dangerously infectious materials, such as tumor-causing viruses; and out of possibilities inherent in recent progress in genetic research through which a new class of enzymes is used to rearrange genetic material. As expressed by Robert Cooke, Science Editor of the *Boston Globe,* two consequences of the new work in genetics are conceived:

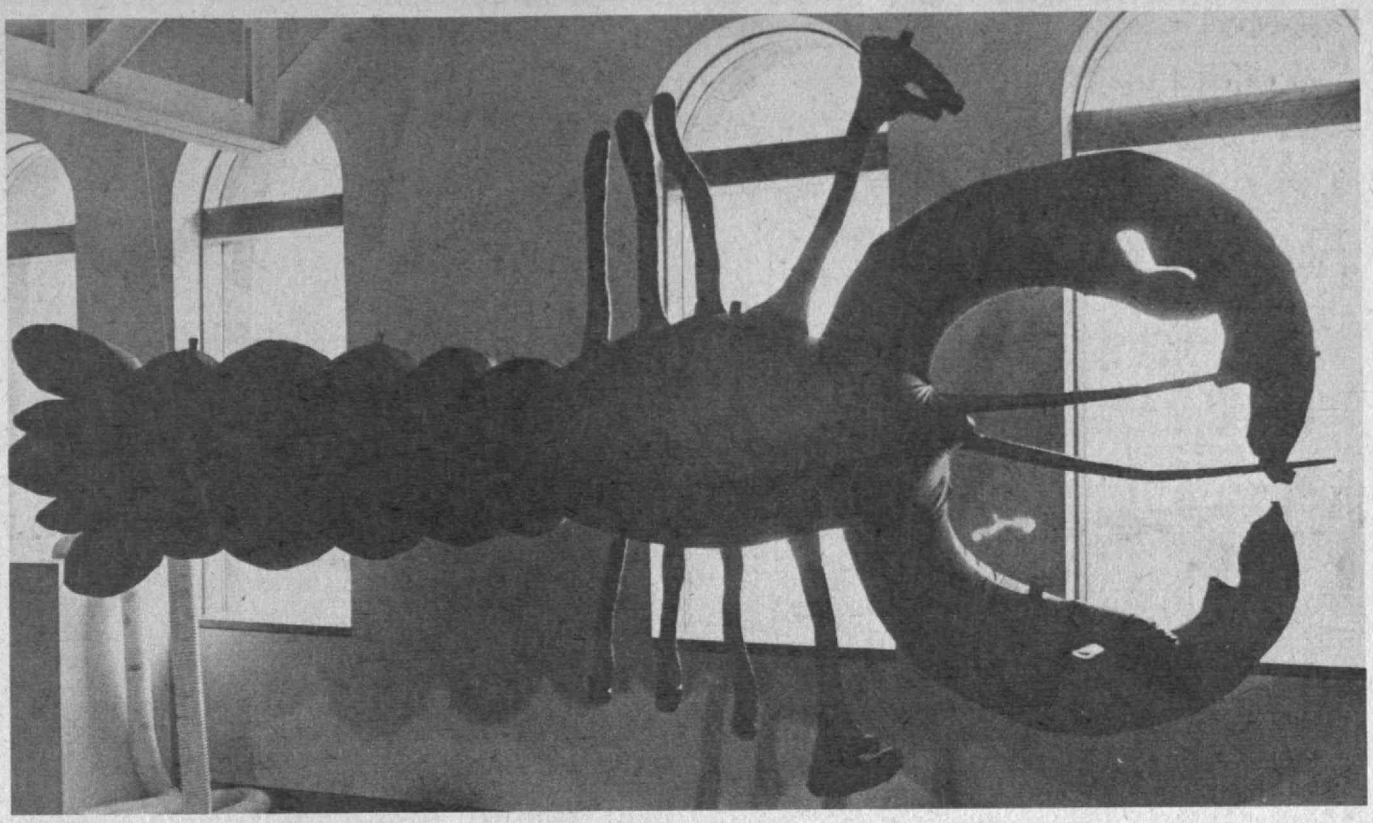
— Rearrangements of genetic material appear to make possible unnatural combinations of genes which could turn out to be viable, creating uncontrollable new disease.

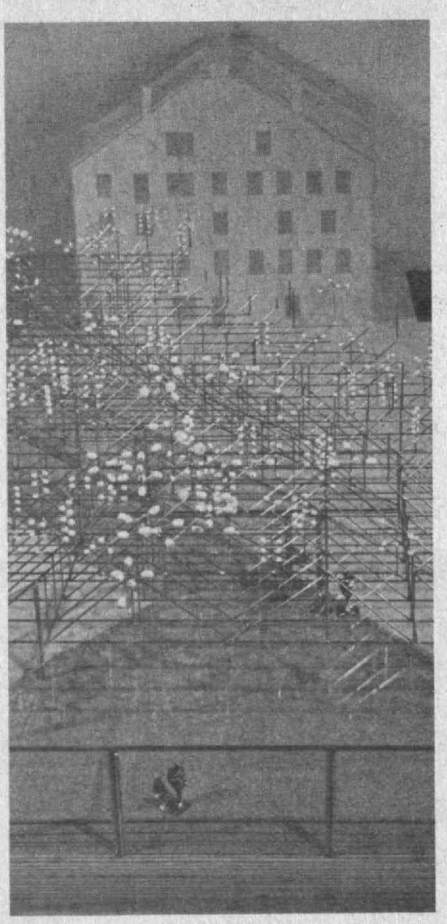
— But research on gene combination stands to help scientists understand how living organisms are controlled, how they malfunction, and how genes differ.

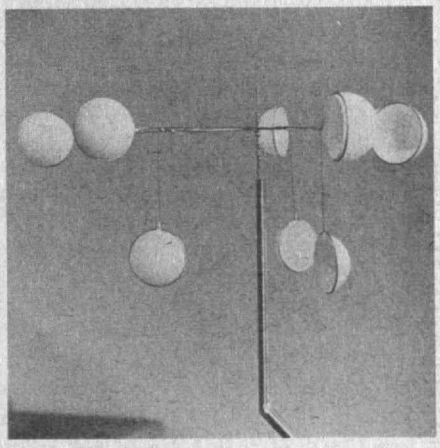
Guidelines of the National Institutes of Health specify the expected levels of danger for different experiments and require that containment methods — especially escape-proof laboratory equipment — be used. The M.I.T. committee will review proposals for studies at M.I.T. which might be hazardous in their use of infectious agents and assess proposed precautions in the light of N.I.H. regulations and independently in the light of M.I.T. needs.

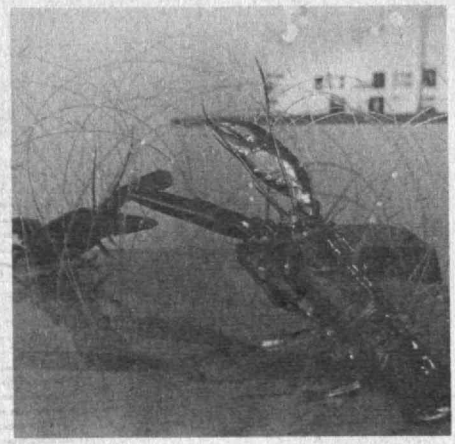
Maurice S. Fox, Professor of Genetics in the Department of Biology, is Chairman of the Biohazards Committee appointed by Walter A. Rosenblith, Provost, to whom it will report. Other members are drawn from the Center for Policy Alternatives, Medical Department, and Department of Nutrition and Food Science.

What about the question of banning research on recombinant DNA, and the control of such work? Professor Fox was asked by Michael D. McNamee, '76, Editor-in-Chief of *The Tech*. He is reluctant to "get dragged into questions" as "political" as those, said Professor Fox. □

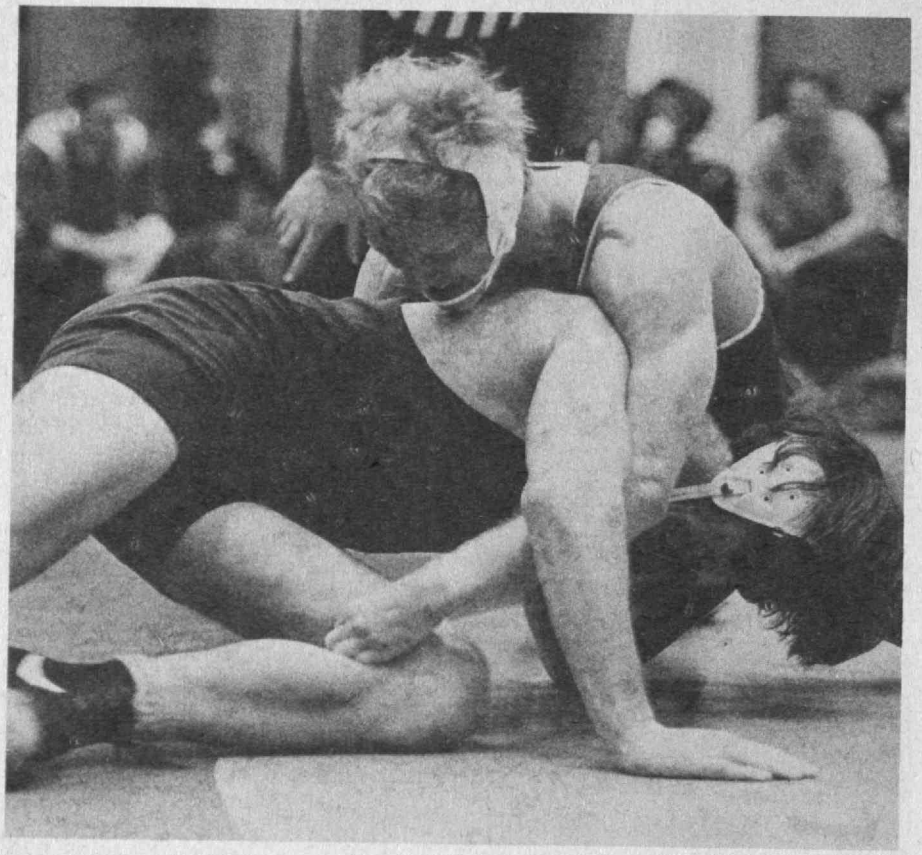


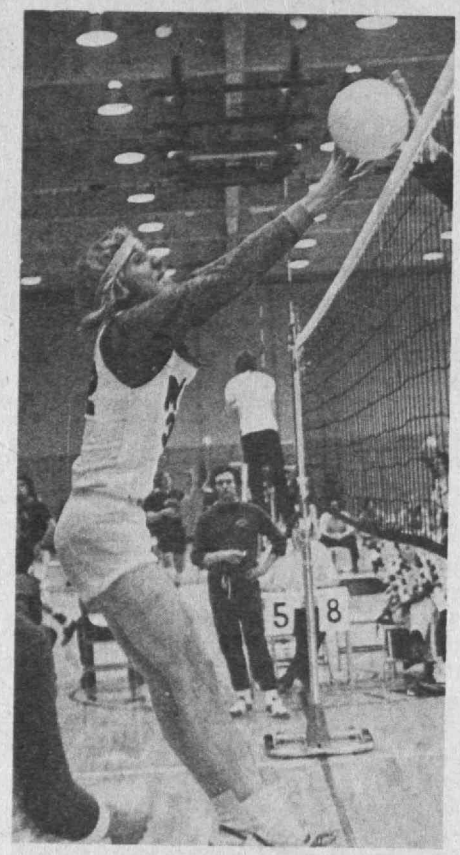




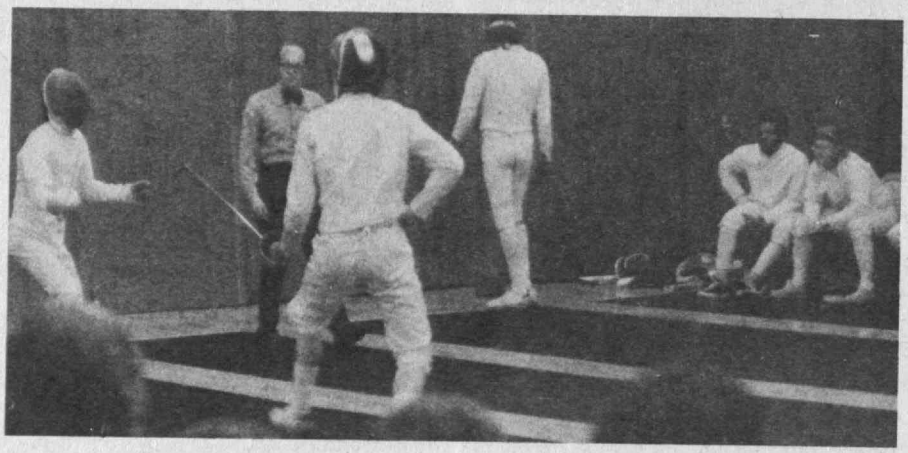


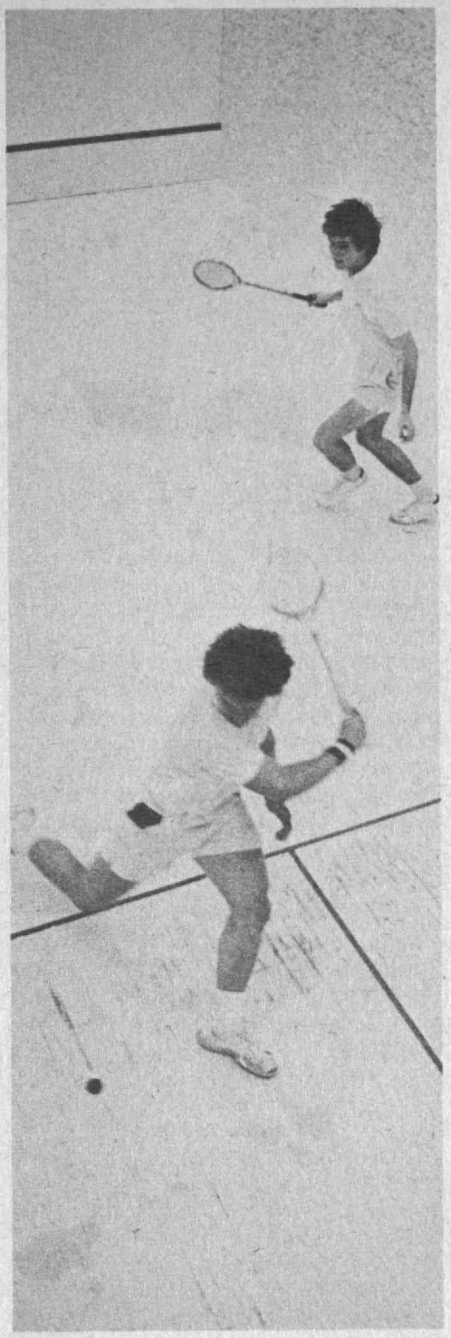
Six artists' visions for the future of Long Wharf, (built out into the Boston Harbor in 1710 as a public way), were shown at the Institute of Contemporary Art in Boston in April. The artists are all former or present fellows at M.I.T.'s Center for Advanced Visual Studies: Lowry Burgess, Michio Ihara, Gyorgy Kepes, Carl Nesjar, Otto Piene, and Harold Tovish. Otto Piene's theme was symbolized by a gigantic bright orange balloon-like shape (top); his ideas included a Lobster Fountain (middle, right.) Michio Ihara designed huge metal "Wind Flowers" (center) that spin individually in the wind, to top a glass enclosed promenade (bottom, left). Harold Tovish, who believes public art must "emerge from the people," designed "Our People" (bottom, right), a wall covered with life-mask casts of people living in the neighborhood. (Photos: David L. Lyon, '69)





Clockwise from top right: Jon W. Johnson, '76, captain and best all-around competitor of the gymnastic team; Larry R. Carley, '76, of the volleyball club, blocks a Springfield spike in the New England Volleyball Championships; Mark J. Smith, '78, (right), New England Champion in foil; Gary J. Spletter, '79, (left) attempts to fight off Harvard's Kelly Jensen. Spletter was one of two victorious grapplers in the wrestling team's 26-11 loss to the Crimson. (Photos: Mark H. James, '78)





Erland Van Lidth de Jeude, '76, (above) presents Valentine's flowers from the M.I.T. wrestling team to co-manager Diane Curtis, '78. Van Lidth de Jeude, after an undefeated dual meet season, captured the New England championship. Since assuming club status last fall, the hockey club (left) enjoyed its best season in recent memory: 8-10-1. Top left: M.I.T.'s number one squash player Frank H. Fuller, '77, (right) defeats Fordham opponent. (Photos: Stan Grossfeld, from the Boston Globe, *above, and Richard F. Reihl, '78)*

Winter Sports Wrap-Up

The Sports Desk
David A. Dobos, '77

The addition of three new varsity status sports for women — volleyball, gymnastics, and swimming — and a number of superb individual and team efforts marked the winter sports scene. M.I.T.'s eight varsity teams finished the season with a highly commendable 105-74-1 record.

The men's (12-1) and women's (8-1) fencing teams accounted for a great deal of that winning margin. The women placed fourth in the New England championships with freshman Michelle Prettyman earning blue ribbon laurels in the beginners division. Ms. Prettyman (who started to fence only last fall) made M.I.T. history with her accomplishment.

For the seventh consecutive year the men captured the New Englands. Mark Smith, '78, and Rich Reimer, '77, swept to first and second places in foil while teammates Arlie Sterling, '77, and David Dreyfuss, G, did likewise in épée. Silvio Vitale, 26-year mentor of the swordsmen, retires this spring with 13 New England championships and two International Fencing Association "Little Iron Man" trophies credited to his athletes during his tenure.

Senior Erland Van Lidth de Jeude advanced to the finals of the N.C.A.A. Division III heavyweight wrestling championship at Coe College in Iowa before losing to Earl Peregra of St. Lawrence University, 4-1. Still finishing 16-1 for the season, Van Lidth de Jeude captured the New England championship and enjoyed an undefeated dual meet season. The remaining members of the wrestling team put together a fine 12-5 record, finishing runner-up in the Greater Boston meet and sixth in the New Englands. Steve Brown, '77 (150 lbs.) was M.I.T.'s only G. B. L. winner and Werner Haag, '77 (134 lbs.) and Joel Lederman, '76 (190 lbs.)

The N.C.A.A. Backs Down

The M.I.T. athletic philosophy of broad participation and the Division III colleges' right of institutional autonomy scored a number of victories at the January convention of the National Collegiate Athletic Association.

Last August, the N.C.A.A. had passed guidelines limiting the sizes of squads (*see December, p. 111*). Now these restraints placed upon member universities have been rescinded.

Besides repealing the squad limitations rule, the N.C.A.A. in January defeated legislation which would have restricted the number of games played per season, reduced the length of a team season (including practices), and limited the cost and scope of varsity awards. A move to extend the unused fourth year of eligibility to a graduate student attending his undergraduate institution failed to muster the necessary two-thirds majority vote, although it received better than 50 per cent.

For M.I.T., the N.C.A.A. action means that no student on an intercollegiate team will be discouraged from competing because of an arbitrary limit on squad size. In particular, M.I.T.'s 55-man indoor track squad will be able to use its depth against schools whose teams are smaller. Also, universities will now be able to resolve their own financial matters for themselves without tangling with N.C.A.A. rulings. — *David A. Dobos, '77*

placed third and sixth respectively in the New Englands.

Men's basketball fashioned its best season in four years. The cagers' 9-11 record could easily have been 15-5 as overtime losses to Tufts and Suffolk, the two top New England small colleges, and four other defeats by five points or less clouded an otherwise successful year. Senior Campbell Lange set a new all-time career scoring mark, tallying 1,699 points during his four-year stay to lift him more than 200 points above that of Harold Brown, '72. Teammate senior Peter Jackson's 954 career rebounds broke the record of 860 by Bill Eagleson, '64. Jackson scored 1,356 points to place him fourth on the all-time career list.

The women's basketball team finished at an even 10-10 for the year. The season's highlight was the squad's third-place performance at the University of Chicago tournament February 5-7. There the women defeated Oberlin and Northwestern while losing to Brown and Chicago in the round-robin event. The winter also brought a first-ever victory over Radcliffe and an invitation to the Massachusetts Association for Intercollegiate Athletics for Women post-season state tournament.

While the fledgling women gymnasts were struggling to a 3-7 record in their first varsity season, freshman Elaine Sears became the first in M.I.T.'s history to qualify for the Eastern A.I.A.W. championships at Cornell. Ms. Sears earned the right to compete on the uneven parallel bars by scoring at least eight points out of ten twice during the regular season.

Senior Jerome Dausman led the rifle team (23-4) to a second-place New England league finish (14-4) when he captured the conference individual title. His score of 284 (out of a possible 300) in the sectionals set a new M.I.T. record. The squad's combined total of 2,213 in the league finals established yet another M.I.T. mark.

Rifle's counterpart, the pistol team (9-3), completed its highly successful season by shooting runner-up to the Air Force Academy in both the Intercollegiate Rifle Sectionals national and international championships. Senior Steve Goldstein captured both individual honors, scoring 860 (out of 900) in the national event and 821 (also out of 900) in the international competition.

The indoor track team turned the tables on a number of opponents en route to a 6-2-1 dual meet record. The thinclads averaged '74-'75 losses to Coast Guard, Williams, Tufts, and Bowdoin. Sprinter/hurdler Richard Okine, '77, led the M.I.T. attack with 71 dual meet points. Okine captured the Eastern Championships in the 45 yard high hurdles, was runner-up in the Greater Bostons, and placed third in the New Englands. Senior Jeff Baerman's, 4:14.4 mile missed the M.I.T. record of Ben Wilson, '70, by one second. Baerman's fourth place in the Greater Boston mile run marked the first time in eight years that an M.I.T. athlete had placed in that event. Freshman Barry Bayus, running a 9:28.2, shaved nine seconds from Wilson's two-mile run record. The two-mile relay team of Baerman, Bayus, John Dillon, '78, and Joe Egan, '77, shattered that event's M.I.T. mark of 8:03.1 with a sizzling 7:53.8 clocking at the New Englands. □

"One if by Land, Two if by Sea . . ." A Lesson in Lasers from Paul Revere

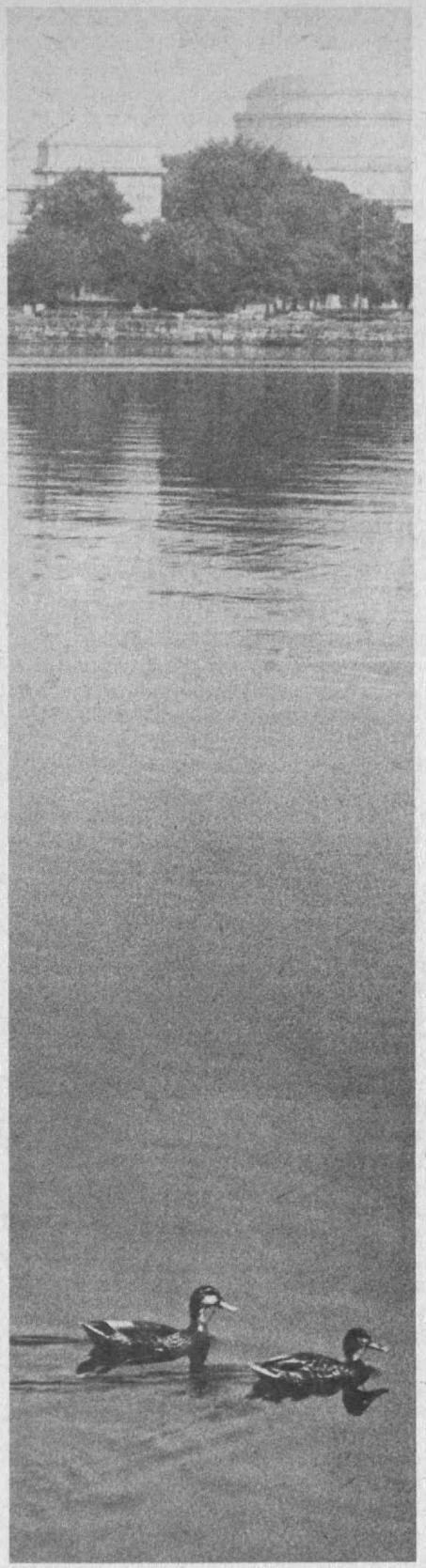
Some think the story almost apocryphal, but Burton R. Clay of RCA, Inc., in Burlington, Mass., says the colonists' use of lanterns from the Old North Church to send Paul Revere on his historic ride to Lexington and Concord was "a landmark for optical communication in America."

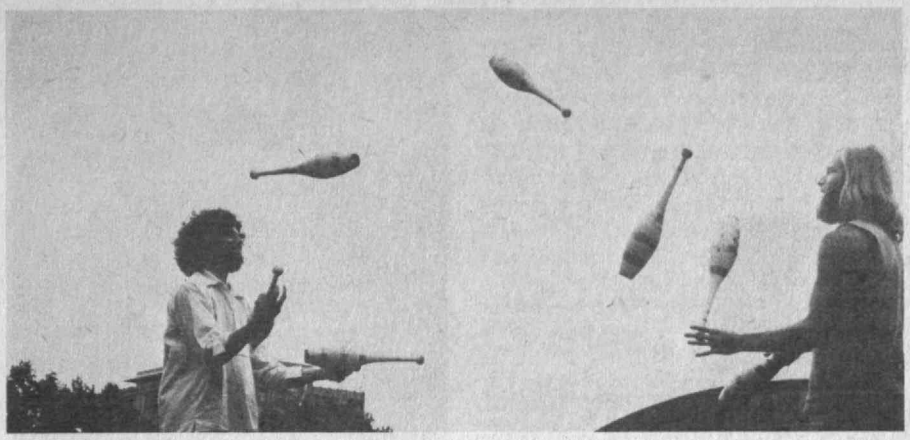
Mr. Clay is Vice President of the Optical Society of America, and when the Society came to Boston for its annual meeting late last year he decided to make his point by asking Professor Cardinal Warde and some of his students at M.I.T. to open the meeting with a signal sent by laser from Old North Church to the new Prudential Center.

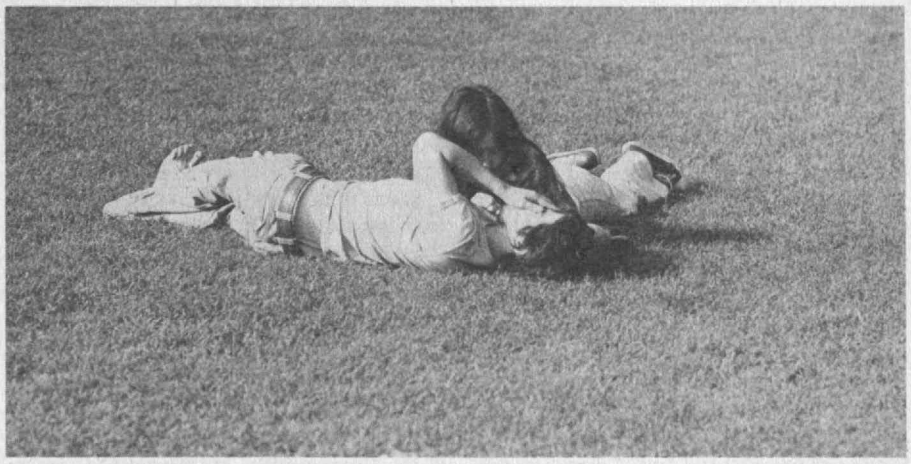
Lawrence E. Schmutz, '71, a graduate student in the Department of Electrical Engineering and Computer Science, is at work on the Skywalk of Boston's Prudential Tower with a telescopic receiver aimed at the Old North Church. Four M.I.T. undergraduates are at the Church with a laser transmitter and a tape-recorded greeting from Mayor Kevin H. White to members of the Optical Society of America. "I think it works!" exclaimed Professor Cardinal Warde of M.I.T. when the optical communications channel began to deliver Mayor White's message to the opening session of O.S.A.'s annual meeting at the Prudential Center late last year.

Though simple in theory, the job turned out to be almost more than Professor Warde and his students had bargained for. But in six days of work with borrowed and scrounged equipment, the group put together a system that "worked better than expected" — a difficult technical feat, thinks Professor Warde, because the laser beam had to be weak enough to be safe and yet strong enough to conquer air turbulence and pollution in the two-mile line-of-sight transmission path.

Four days before the meeting, Lawrence E. Schmutz, '71, a graduate student, Rodney A. Jacobs, '76, John D. Cox, '79, Robert F. Dillon, '79, and David B. Tuckerman, '79, worked until 3 a.m. to prove their helium-neon laser system between the Green Building and the Westgate Tower on the M.I.T. campus. That milestone achieved, they moved their laser transmitter to the belfry of Old North Church and their telescopic receiver to the Skywalk of the Prudential Tower — in a rainstorm. The rain continued, heavy enough to scatter the laser beam and halt communications, until the day of O.S.A.'s opening, and "we were left with a one-shot try from the Church to the Prudential," says Professor Warde. It worked: a taped greeting came from Kevin H. White, Mayor of Boston, to O.S.A. on the two-mile pencil of ruby-colored light. □







Spring came early — and suddenly — in Cambridge this year. With it came the annual release from dark corridors and classrooms — and an orgy of cleaning and fixing — including a surplus of patients in the Physical Plant Department's greenhouse/plant clinic. (Photos: Calvin Campbell and Daniel F. Lam)

People

H. J. Zimmermann

Having already assured the smooth operation of countless alumni functions at M.I.T., Miles P. Cowen in 1965 was made an Honorary Member of the Alumni Association. A decade later, approaching retirement, he was given the Association's highest honor in recognition of distinguished service – the Bronze Beaver. The picture shows Howard L. Richardson, '31 (left), President of the Alumni Association, making the presentation at the 1975 Alumni Officers Conference.

Zimmermann Leaving R.L.E.; Seek Successor

For only the third time in its 30-year history, the Research Laboratory of Electronics is seeking a new Director: Henry J. Zimmermann, S.M.'42, Professor of Electrical Engineering, has announced he will leave the post of R.L.E. Director in June to return to full-time teaching and research.

Professor Zimmermann has headed the Laboratory — it is the oldest and most famous of several interdepartmental laboratories at the Institute — for 15 years, just half of R.L.E.'s 30-year history. The Laboratory was founded at the end of World War II to continue and develop as an educational opportunity the program of basic research carried out by the Radiation Laboratory; Julius A. Stratton, '23, then Professor of Physics, was its first Director, followed in turn by Albert G. Hill (1949 to 1952) and Professor Jerome B. Wiesner (1952 to 1961).

Thomas F. Jones, Sc.D. '52, Vice President for Research to whom R.L.E. reports, calls attention to the special contributions of Professor Zimmermann in strengthening the Laboratory's "educational dimension" during his tenure as Director: "Hundreds of faculty and students from more than a dozen academic departments in the Institute have found support, encouragement, and assistance there for diverse research ranging from molecular beam studies to phonetic studies of language and speech," he notes; more than 1,600 student research theses have been written there in the past 15 years, and many areas now in the M.I.T. curriculum were pioneered there as research. This year R.L.E.'s association extends to 100 faculty members, and their projects include participation by about 300 graduate and 125 undergraduate students.

An *ad hoc* search committee consisting of Dr. Jones, Professor Wilbur B. Davenport, Jr., Sc.D. '50, head of the Department of Electrical Engineering and Computer Science, and Professor Herman Feshbach, Ph.D. '42, Head of the Department of Physics, is seeking a successor. □

Miles Cowen Retires After 33 Years

"When there is a public occasion and you see Miles Cowen standing at the back of the hall with his black book under his arm, it's a reassuring feeling. . . . If he looks worried, that's even better, because it means he's thought of something you have not considered."

That was the tribute of Howard W. Johnson, Chairman of the Corporation, to Miles P. Cowen, Assistant Director of the Physical Plant, at a party for Mr. Cowen early in the winter.

A more formal tribute last fall from the Alumni Association — a presentation of the Bronze Beaver: "The success of countless events through which alumni have come to better understand and love the Institute has depended upon his foresight, wisdom, and meticulous concern for every detail. His unselfish, devoted service on behalf of alumni has won him a lasting place in the annals of his adopted alma mater."

Both accolades came to Mr. Cowen in connection with his retirement after 33 years in M.I.T.'s Physical Plant. He came to the Radiation Laboratory in 1942 with a fresh, new degree from the Rhode Island School of Design, and after World War II he joined Physical Plant as Building Services Supervisor. Later he was Assistant to the Superintendent and Superintendent for Building Services; and finally in 1972 he became Assistant Director with responsibilities for special services.

It was in this assignment that Mr. Cowen was able to devote full attention to such public events as Commencements, inaugurations, alumni meetings and reunions, and major conferences.

In all these capacities, Mr. Cowen proved himself "the most reliable man I have ever known," said William R. Dickson, '56, Director of Physical Plant; "you don't replace Miles Cowen," he told 300 members of the M.I.T. community gathered as well-wishers. □

Alfred P. Sloan's Affection for M.I.T.: "Technological," not "Academic"

". . . I never knew anyone else even faintly like him. He was unique. He was a truly great man . . . a continuous delight, a continuous stimulation."

Warren Weaver was a Trustee of the Alfred P. Sloan Foundation from 1956 to 1967 and Vice President from 1959 to 1964, and its officers naturally turned to Dr. Weaver for a tribute to the late Alfred P. Sloan, Jr., '95, on the 100th anniversary of his birth in 1875. The quotation is the warmest personal appraisal in that tribute, which has just been published by the Foundation.

Mr. Sloan was impatient of all but what he regarded as truly "creative" philanthropies, supporting "significant and innovative activities" which would not otherwise have been possible, writes Dr. Weaver, and "he was the primary source of the ideas" for the Foundation's activities. These were centered during Mr. Sloan's lifetime in basic research, especially in science; economics, management; cancer research; and M.I.T.

Mr. Sloan's gifts to the Institute, personally and through the Foundation, were over $56 million during his lifetime — "an almost staggering total of financial support from one individual to his alma mater," says Dr. Weaver, and he speculates that "there must indeed be few comparable instances in the history of American philanthropy." Why this remarkable generosity to the Institute? Because, says Dr. Weaver, M.I.T. shared with Mr. Sloan "a dedication to basic research"; and because M.I.T.'s leadership "commanded Mr. Sloan's complete confidence and his enthusiastic support." (Mr. Sloan always spoke of James R. Killian, Jr., '26, as "Keelyan" — a result, thinks Dr. Weaver, of deafness which afflicted Mr. Sloan for most of his life.)

Mr. Sloan was contemptuous of most academics. "They may rust out," he once said to Dr. Weaver, "but they never work

hard enough to wear out." Yet he seemed to make an exception of M.I.T. Dr. Weaver recalls asking Mr. Sloan about that. "He replied with a vigor unusual, even for him, that 'M.I.T. is *not* an academic institution, it's a *technological* institution!' " Dr. Weaver recalls. □

Individuals Noteworthy

Kudos: Honors, Awards, Citations

To **J. Samuel Jones,** Associate Director of the Student Financial Aid Office at M.I.T., and **B. Alden Thresher,** '20, former Director of Admissions at M.I.T., the Edward S. Noyes Award for Outstanding Service to the College Entrance Examination Board of New York . . . to **Victor F. Weisskopf,** Institute Professor Emeritus of Physics at M.I.T., the Oersted Medal of the American Association of Physics Teachers . . . to **Samuel C. C. Ting,** Professor of Physics at M.I.T. and leader of the team that discovered the J particle, the Ernest Orlando Lawrence Memorial Award for 1975 of the Energy Research and Development Administration.

To **Bruce A. Einstein,** '63, Assistant Professor of Electrical Engineering at Drexel University, the C. Homes MacDonald Outstanding Young Electrical Engineering Teacher Award of the National Electrical Engineering Honor Society . . . to **Gary Vanderweil, Jr.,** S.M. '63, principal of the firm of R. G. Vanderweil Engineers, Inc., Boston, the Young Engineer of the Year Award of the Massachusetts Society of Professional Engineers . . . to **John Leslie,** '32, Chief of the Planning and Engineering Division of the New England Division of the Corps of Engineers, the New England Award of the Engineering Societies of New England.

To **Don G. Friedman,** Sc.D. '54, whose research at The Travelers Insurance Co. has contributed to rate-making, claim settlement and establishing reserves, the Outstanding Contribution to the Advancement of Applied Meteorology award of the American Meterological Society . . . to Colonel **William E. Pace,** S.M. '67, Chief of the Veterinary Education Branch of the Education Division at the U.S.A.F. School of Aerospace Medicine, Brooks A.F.B., his second award of the Legion of Merit . . . to **Gerald L. Katell,** '62, of Parking Structures International, Los Angeles, membership in the Young Presidents' Organization, Inc.

Roger F. Sellew, M.S. '62, Director of Planning and Control of the Process Chemicals Division of Monsanto Co., named "Man of the Year," the highest award of the reinforced plastics industry . . . to **Sydney B. Karofsky,** '37, Chairman of the Board of Northeastern Wallpaper Corp., the 1976 Justin P. Allman Award of the Wallcovering Wholesalers Assn. . . . **John J. Greene,** S.M. '49, Supervisor of Professional Development for Texaco in Beacon, N.Y., elected a Fellow of the American Institute of Chemical Engineering . . . **Haskell R. Gordon,** '38, an owner of The Fair in Worchester, Mass., elected to the board of fellows of Brandeis University . . . **Ithiel de Sola Pool,** Arthur and Ruth Sloan Professor of Political Science at M.I.T., named at Phi Beta Kappa Visiting Scholar for 1976-77 by the United Chapters of Phi Beta Kappa.

To **James R. Killian,** '26, Honorary Chairman of the M.I.T. Corporation and of the Board of the Corporation for Public Broadcasting, the Ralph Lowell Award, the highest award of the Corporation for Public Broadcasting . . . to **Peter W. Hwoschinsky,** '71, a private pilot, the first William E. Jackson Award of the Radio Technical Commission for Aeronautics of Washington, D.C., for his thesis on the OMEGA navigation system for general aviation . . . to **John F. Elliott,** Sc.D. '49, Professor of Materials Science and Engineering at M.I.T., the James Douglas Gold Medal "for distinguished teaching and contributions to the broad spectrum of thermodynamics of extractive metallurgy" of the American Institute of Mining, Metallurgical and Petroleum Engineers.

Three M.I.T. sophomores won prizes in the first "Amateur Scientist Contest" sponsored by the American Association for the Advancement of Science and *Scientific American* magazine: **Peter D. Esser** and **George Pastrana** shared the first prize with another entry for the grating spectrograph; and **Douglas J. Ely** shared second prize for his parabolic liquid mirror of mercury . . . to **Val M. Heinz,** a graduate student in the Department of Aeronautics and Astronautics, first prize for his paper, "Analysis of a Space-Based Fuel Station," presented at the American Institute of Aeronautics and Astronautics National Student Conference in Washington, D.C. . . . **Vera Kistiakowsky,** Professor in the Department of Physics at M.I.T., was noted in *Time* magazine's article, "Women of the Year."

Sloan Fellowships for Basic Research have been awarded to four assistant professors at M.I.T.: to **Richard R. Schrock** and **Edward I. Solomon** of the Department of Chemistry, and **John D. Joannopoulos** and **Paul C. Joss** of the Department of Physics.

Counselors: Officers, Directors, Advisors

Jerome B. Wiesner, President of M.I.T., elected to Chairman of the Advisory Council of the Office of Technology Assessment . . . **James A. Newman,** '37, Vice Chairman of the management consulting firm of Booz, Allen and Hamilton, Inc., to a director of Industrial National Corp. . . . **Arnold O. Putman,** S.M. '47, President of Rath and Strong, Inc., to President of the Institute of Management Consultants . . . **David Adler,** Professor of Electrical Engineering at M.I.T., to the executive committee of the Division of Solid State Physics of the American Physical Society . . . **Albert F. Clear,** '42, Executive Vice President of The Stanley Works of New Britain, Conn., to a director of the New Britain Bank and Trust Co.

Bryon T. Atwood, Jr., '53, President of Atwood and Morrill Co., Inc., to the board of directors of Naumkeag Trust Co., Salem, Mass. . . . **Lee Grodzins,** Professor of Physics at M.I.T., to Chairman of The

American Physical Society Forum on Physics and Society . . . **Lucius P. Gregg, Jr.,** M.S. '61, Vice President of the First National Bank of Chicago, will chair a new committee on minority-group education and employment within the Commission on Human Resources of the National Research Council . . . **Brian B. Schwartz,** staff member of the Francis Bitter National Magnet Laboratory, served on the panel of judges for the 1976 science writing prize in physics and astronomy of the American Institute of Physics and the United States Steel Foundation.

Eric S. Beckjord, S.M. '56, appointed to Director of the Division of Reactor Development and Demonstration of the Energy Research Development Administration (E.R.D.A.) . . . **John W. Crawford,** S.M. '46, to Executive Assistant to Dr. Richard W. Roberts, Assistant Administrator for Nuclear Energy of E.R.D.A. . . . **C. Martin Stickley,** S.M. '58, to Director of the Division of Laser Fusion in E.R.D.A. . . . **Arnold B. Peinado, Jr.,** S.M. '53, President of Peinado, Peinado and Navarro, Consulting Engineers, to a three-year term as President of El Paso National Bank, El Paso, Tex. . . . **Clarence D. Davis,** '35, Professor of Obstetrics and Gynecology at the Yale University School of Medicine, to Educational Director of Obstetrics and Gynecology at St. Vincent's Hospital . . . **James S. Bruce,** S.M. '39, to Director of Corporate Relations of Eastman Kodak Co., Rochester, N.Y.

Career Changes

William R. Corcoran, Ph.D. '71, Director of Nuclear Safety for the Power Systems Group at Combustion Engineering, Inc. . . . **George S. Cherniak,** S.M. '41, a vice president of T.R.W. Systems and Energy, now also Acting General Manager of the Energy Products Group in Los Angeles . . . **Robert B. Saba,** S.M. '61, Director of Consulting Services of United States Steel Engineers and Consultants, Inc. . . . **David V. Stallard,** '50, Consulting Engineer at the Missile Systems Division of Raytheon Co. . . . **Theodore J. Slosek,** '54, Manager of Marketing for the Irradiation Processing Operation of General Electric Co.

Willem H. Thorbecke, '48, a vice president of Dravo Corp., Pittsburgh, Penn. . . . **Gary A. Mellinger,** Sc.D. '71, Manager of the new Polymer Processing Unit at the General Electric Research and Development Center . . . **Kenneth C. Bushway,** '48, Manager of Technical Services of Wyrough and Loser, Inc., Trenton, N.J. . . . **Howard D. Chapman,** '51, Vice President of Marketing for List Industries, Inc., Harvey, Ill. . . . **Arthur Bisberg,** M.S. '56, General Manager of the Environmental Equipment Division of E. G. and G. . . . **Donald L. Isaacs,** M.S. '74, Technical Planning Officer of Baystate Corp., Boston.

William E. Banton, S.M. '64, Director of Special Projects at the Boston office of Western Electric Co. . . . **Evan T. Jones,** '56, Assistant Director of the Emulsion Research Division of Eastman Kodak Co. . . . **Jimmy Hill,** '59, Vice President of Operations of the Eastern Steel Division of U.S. Steel . . . **Donald C. Berkey,** '42, General Manager of Energy Systems and Technology Division of General Electric Co.

George R. Hecker, S.M. '62, Director of Worcester Polytechnic Institute's Alden Research Laboratories in Holden, Mass. . . . **Donald R. Miller,** '50, now Director of Professional Services for the international management consulting firm of Cresap, McCormick and Paget Inc., in addition to his positions as Vice President and Eastern Region Manager . . . **Jack W. Wolter,** S.M. '74, Vice President of Manufacturing and Engineering for the Construction Products Division of W.R. Grace and Co. . . . **Rutherford Harris,** '37, Assistant to the President of Arkwright-Boston Manufacturers Mutual Insurance Co. . . . **Clarence W. Malick,** '64, Assistant General Counsel and Assistant Secretary of I.T.T. Thorp Corp. . . . **Paul L. McGill,** '51, Commercial Vice President in the Nuclear Power Systems division of Combustion Engineering, Inc.

Tom Higgins, '49, Principal Staff Engineer in the Engineering Department of Union Carbide, South Charleston, W. Va. . . .

Raymond Ghosn

Raymond S. Ghosn, S.M. '50, Professor of Architecture and Dean of Engineering at the American University of Beirut, was killed by a deranged student involved in civil violence in Lebanon on February 17.

Mr. Ghosn held two master's degrees from M.I.T. — in civil engineering and architecture. He had been active in alumni affairs and was a leading representative of the Institute in Lebanon. □

Albert O. Seeler, 1915-1976

A. O. Seeler

Dr. Albert O. Seeler, Head of the Medical Department since 1960, died from severe influenza and complications at Massachusetts General Hospital on February 12; he was 60.

Before joining the M.I.T. Medical Department as a physician, Dr. Seeler had been engaged in private practice from 1949 to 1956, and during that period he held appointments at Mount Auburn Hospital, Harvard Medical School, Boston City Hospital, and the Boston Veterans' Administration Hospital.

He became M.I.T.'s Physician-in-Chief in 1959, and for 16 years since then he was the chief guardian of the health of the Institute community as well as the administrator of increasingly comprehensive medical services. His careful reports on the progress of contagious diseases in the M.I.T. community were a feature of both Academic and Administrative Council meetings.

Dr. Seeler, a native New Englander, studied at Harvard College and Harvard Medical School (M.D. 1938). After internship at the Memorial Hospital in Worcester, Mass., he was a pharmacologist at the Merck Institute for Therapeutic Research in Rahway, N.J., from 1940 to 1944 and the Institute's Assistant Director from 1944 to 1945.

During Dr. Seeler's tenure as Head of the M.I.T. Medical Department, visits to it rose from 30,000 to nearly 110,000 in 1974-75; and during the same period there was a steady increase in the extent and coverage of medical services offered to the community. The most recent in a series of innovations, the M.I.T. Health Plan now offers an alternative to Blue Cross-Blue Shield medical coverage for 1,700 members of the staff and faculty and their families. □

Gordon B. Wilkes, 1890-1976

Gordon B. Wilkes, '11, Professor of Heat Engineering, Emeritus, in the Department of Mechanical Engineering, died at the Cape Cod Hospital, Hyannis, on February 16; he was 86.

Professor Wilkes joined the M.I.T. staff upon graduating from the Institute in 1911; though his degree was in mechanical engineering, his first teaching assignment was in the Department of Physics. Twenty-three years later he moved back to the Department of Mechanical Engineering to become Professor of Heat Engineering, and from 1934 until his retirement in 1954 he presided over a teaching laboratory of furnaces and heat exchangers in the basement of Building 7.

Professor Wilkes was the author of numerous scientific papers and of the book, *Heat Insulation*, and he was well known throughout the U.S. in the field of his principal teaching and research. He moved to Orleans on Cape Cod following retirement. □

Ruth McG. Lane, 1888-1976

Ruth McG. Lane, who served in the M.I.T. Libraries from 1936 until 1958 and for much of that time was Librarian of the great Vail Collection in electrical engineering, died on February 12. She was 88.

Before coming to M.I.T., Mrs. Lane had worked with Melvil Dewey, originator of the Dewey Classification System; though she retired from her duties in the Engineering Library in 1953, Mrs. Lane continued to work part-time with the electrical engineering collections until 1958. □

Deceased

Richard O. Elliot, 1896; March 5, 1976; 5 Elliot St., Thomaston, Maine.

William G. Ball, '05; March, 1976; 6311 Fordham Pl., Bradenton, Fla.

James E. Rogers, '05; March, 1975; 46 Coddington Ave., Staten Island, N.Y.

Alva B. Court, '10; February 16, 1976; P.O. Box 1783, Annapolis, Md.

Albion R. Davis, '12; March 12, 1976; 38 Sabrina Rd., Wellesley, Mass.

George L. Uman, '12; February 20, 1976; 1716 Carmona Ave., Los Angeles, Calif.

Paul V. Cogan, '13; July 7, 1975; 276 East Macada Rd., Bethlehem, Penn.

C. Clinton Carpenter, '16; March 15, 1976; 1433 N. Bay Shore Dr., Virginia Beach, Va.

Poh Y. Hu, '17; October 21, 1975; Leong Son See, 371 Race Course Rd., Singapore 8, Singapore.

James G. McDougall, '17; February 14, 1976; 143 Atlantic Ave., Marblehead, Mass.

Haig N. Solakian, '17; January 30, 1976; 241 Pine Orchard, Branford, Conn.

Harold Sterner, '17; March 12, 1976; 340 East 63rd St., New York, N.Y.

Dana A. Barnes, '21; June 7, 1975; 921 W. 6th Ave., Anchorage, Alaska.

Andrew I. McKee, '21; January 24, 1976; 30 Guthrie Pl., New London, Conn.

Daniel Noce, '21; February 17, 1976; Covington Farm, R.R. #1, Box 192, Sperryville, Va.

Walter T. Kirley, '22; February 25, 1976; 26 Riverside Dr., Waltham, Mass.

John Ward Poole, '22; July 25, 1975; P.O. Box 336, Jaffrey Ctr., N.H.

Irwin J. Smith, '22; July 20, 1975; Tremaine Hse. Dutch Village Mevauds, Albany, N.Y.

Julius W. Werra, '22; October 9, 1975; 3800 No. 92nd St., Milwaukee, Wis.

Benjamin P. Bullman, '23; March 13, 1976; 9 Sligo Rd., Yarmouth, Maine

Earl C. Palmer, '23; February 6, 1976; 123 Oleander Dr., Jasmine Lakes, North Port

Ritchey, Fla.

Roy G. Rincliffe, '23; February 3, 1976; 633 Strath Haven Ave., Swarthmore, Penn.

Mitchell V. Allen, '24; November 21, 1975; 17 Cricklewood Pl., St. Louis, Mo.

William F. Behrman, '24; June 19, 1975; 865 Boulevard, Westfield, N.J.

Albert B. Donkersley, '24; June 10, 1975; 444 Mesnanticut Valley Pkwy., Providence, R.I.

Otto E. Kirchner, '24; February 5, 1976; 9640 N.E. 32nd St., Bellvue, Wash.

Sheldon T. Hare, '25; October 22, 1975; 48 Auburn St., Concord, N.H.

Oliver R. Etheridge, '26; January 22, 1976; 635 S. Seigel St., Decatur, Ill.

Marc F. LeDuc, '26; July 4, 1975; 1360 West Plumb Lane, Reno, Nev.

Malcolm A. MacDuffie, '26; February 24, 1976; Bernard, Maine

Francis P. Romanoff, '26; December 19, 1975

Arthur C. Sutton, '26; January 27, 1976; 281 Magellan Ave., San Francisco, Calif.

Albert F. Briggs, '28; December 8, 1975; 5870 Townhouse Ln., Beaumont, Tex.

George M. Hoffman, '28; August 5, 1975; 2525 Carousel Dr., Springfield, Ohio

David Graham, '29; January 24, 1976; Village of Golf, R.F.D. 755, Delray Beach, Fla.

Warren H. Martell, '30; January 16, 1976; 666 E. Ocean Blvd. Apt. #1207, Long Beach, Calif.

Dwight S. Ashley, '32; October 19, 1975; 3411 Martha Custis Dr., Alexandria, Va.

Edward S. Clark, '32; March 18, 1975; 8800 Eton Ave. 40, Canoga Park, Calif.

Peter Laban, '32; September 9, 1975; P.O. Box 714; Yankton, S.D.

James P. Stewart, '33; January 10, 1974; 141 Valley Run Dr., Cherry Hill, N.J.

John F. Keefe, '35; February 26, 1976

Perry H. Ware, '35; January 29, 1976; 845 MacArthur Dr., Pittsburgh, Penn.

Arnold H. Clarke, '36; March 12, 1976; Box 142, Pleasantville, N.Y.

John R. Cook, '38; February 18, 1976; Troutbridge Farm, Riegelsville, Penn.

Victor P. Starr, '38; March 15, 1976; 49 Osborne Path, Newton Center, Mass.

David P. Triller, '39; February, 1976; 225 East North St., Apt. 2805, Indianapolis, Ind.

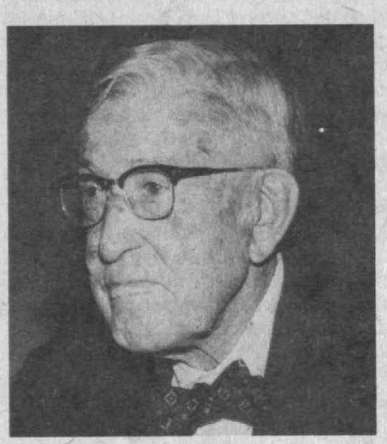
Arthur T. Higgins, '40; July 30, 1975; 8975 Champagne Blvd. Space 67, Escondido, Calif.

Robert D. Mellen, '41; January 31, 1976; Churchill Pl. R.D. #1, Big Flats, N.Y.

Arthur Y. Taylor, '46; January 30, 1976; 134 Front St., Marblehead, Mass.

Lester N. Lechter, '47; January 28, 1976; 1 Fuller Pl., Dedham, Mass.

Class Review



Richard O. Elliot, '96

96

Richard O. Elliot, the oldest living graduate of M.I.T. and the last survivor of the Class of '96, died in Maine on March 5, just four weeks after celebrating his 103rd birthday. (That event was marked by a family get-together and telegrams were received from the governor of Maine and from President Ford.) Born in Thomaston, Maine, on February 6, 1873, he was the son of George and Mary Libby Elliot. He was educated in the local schools and after graduating from M.I.T. he returned to his native town and entered the family business of shipbuilding and sailmaking. As president and general manager of the company he guided it from shipbuilding into the coal business in 1913. His interest in banking started about 1910 and in 1927 he left the family business to become president of the Thomaston National Bank, a position he held until 1960. He continued as a director until two years ago.

Mr. Elliot was active in civic affairs all his life. While still a college student he was one of the founders of the Thomaston Public Library and for many years was president of its board of trustees. At various times he was a member of the school board, a selectman and the town moderator. In 1913 he served in the state legislature as a representative and in 1923 was senator from his county. For 80 years he had been a member of the Knights of Pythias and was a Mason and Shriner over 50 years.

Mr. Elliot was married to the former Lavinia Grant and he is survived by their daughter, Mrs. Madeline E. Bulkeley of Marblehead, Mass. There are also six grandchildren, four great-grandchildren and six great-great-grandchildren.

With the above obituary the annals of the class of '96 are closed and the unfinished task of secretary to the class which was left when my father died is now completed. It was assumed as a "labor of love," for I knew of his loyal feelings towards M.I.T. and his class. To all those who helped in gathering bits of news and to those at the *Review* — thank you. "Ave atque vale." — **Clare Driscoll,** Good Hope School, Frederiksted, St. Croix, Virgin Islands 00840

05

I regret to report that **William G. Ball,** Acting Class Secretary, passed away on February 28, 1976 in Bradenton, Fla., where he had lived for the past seven years. After he was graduated from M.I.T. in mining and geology, he took over the management of the Boston Bundle Wood Co., a family business founded by his father. After this business was sold in 1922, he occupied various management positions with the Associated Factory Mutuals Fire Insurance Co. until his retirement in 1948.

His first wife, Alice Harwood Paul, died in 1937. In 1943, he married Margaret Irene Bowker of Malden, Mass. After his retirement, they resided in Cotuit, Mass., for over 20 years. Both were very active in community affairs there. In the U.S. Power Squadron Mr. Ball earned the highly respected Navigator's "N," not often acquired after the age of 80. He was elected Commander of the Cape Cod Power Squadron and thereafter served as Commander of the U.S.P.S. District 14 in 1964 and 1965. He also served as Chairman of the Santuit-Cotuit Board of Water Commissioners and on zoning committees for that area.

He is survived by his widow, Margaret, who assisted greatly in the preparation of the class notes while he was acting secretary; his son, William G. Ball, Jr., '34; and two grandchildren. — *S.F.*

08

We are sorry to report the death of another classmate **George D. Whittle** of Berkeley, Calif., who passed away on January 25, 1976. He was born in Georgetown, Tex., January 9, 1885; attended Southwestern University in Georgetown, Tex., and graduated from M.I.T. in 1908 with the degree of S.B.

George was a renowned civil engineer. His first ten years he worked in construction and maintenance of the Atchison, Topeka and Santa Fe railroad; then at the City Engineers Office at Los Angeles designing a sewage system; then in the Bureau of Public Works as Bridge Engineer.

With all this experience he opened an office in Berkeley, Calif., for consulting engineering on highways, bridges, drainage, and grade projects.

He was involved in the design and construction of concrete arch bridges in Yosemite Park and steel bridges in Grand Canyon National Park. He supervised construction and ventilation of the Broadway tunnel in Oakland and the Wawona tunnel in Yosemite.

Following the failure of the Tacoma Narrows Bridge, a committee of 25 nationally known engineers including Mr. Whittle made experiments on vibrations on the Golden Gate Bridge and recommended changes in the bracing of the lower chords for stiffening trusses to provide greater safety. He also recommended changes for safety in the construction of the Municipal Auditorium and Exposition Building in Oakland to withstand earthquakes.

George D. Whittle was a member of many engineering societies in California where he was very active and held important positions. — **Joseph W. Wattles III,** Secretary, 26 Bullard Rd., Weston, Mass. 02193.

09

We regret the absence of class notes the past few months, but until recently, aside from a few regrettable obituaries, we have received no communications from our dwindling numbers. However, our president **Art Shaw** sent us a note from his winter resort at Longboat Key, Fla. "I joined the M.I.T. Club of Southwest Florida and found it pleasant to attend some of the meetings. At one of those meetings, we had as guests at the luncheon young new undergraduates at M.I.T. and local high school students who are aiming for admission to M.I.T. I found it pleasant to chat with these young people. It is worthwhile to roll back the years and discover that some of the challenges which beset young people today are not so far different than those which churned around in our heads when we were young. We expect to be back in Auburndale before the first of

May so I hope to attend, at least, the last meeting of the Alumni Council." . . . Earlier we received a card from **Bob Glancy** from Broomall, Penn., stating there are some Glancys among his 22 grandchildren and four great-grandchildren.

We have frequently reported in these notes of the continued activities of **Florence Luscomb** and we continue to receive notices of her current activities, particularly in behalf of equal rights of women. Recently a detailed account in the Providence *Bulletin* stated that she was the principal speaker at a rally in Providence. She still spends her summers in New Hampshire in a cottage near Mt. Chocorua where she cultivates a market garden, and not so long ago she climbed the mountain.

Belatedly we have received a notice that **Denison King Bullens** passed away January 28, 1974 at his home in Southern Pines, N.C. He prepared for the Institute at Newton High School, Mass., where your secretary first met him. At the Institute he was a member of the Mining Engineering Society, Y.M.C.A. and musical clubs in which he was a soloist. After a year's teaching at Penn State College he became a successful metallurgical engineer and was employed by leading metal and steel companies in Pittsburgh and Philadelphia. In 1935 he joined the New England Auto Parts Co., Pottstown, Penn., and in 1954 retired to live in a beautiful estate and mansion known as "Homewood" in Southern Pines, N.C.

We received a note from Mrs. **Thomas C. Montgomery,** Rock Island, Ill., telling of the death of her husband on October 13, 1975, following a month's illness. Thomas was a member of Course V and our records show that he was secretary and treasurer of the Montgomery Lumber Co. of Winner.

Morse W. Rew of Cleveland, Ohio, died in January, 1976. He prepared for the Institute at Grinnell College, Iowa, and at the Institute he was a member of the Civil Engineering Society. In 1922 he was employed by the Cleveland Railway Co. and in 1943 he was appointed chief engineer of the company now called the Cleveland Transit Co. He retired in 1955 at the age of 70, and remained as deputy county engineer for 13 years. He is survived by his wife Lucille, a son and daughter, three grandchildren and one great-grandchild.

John R. Gray, '40, wrote of the death of his father **George H. Gray** on July 25, 1975 in Natick, Mass. — just a few weeks short of his 90th birthday. Your secretary was closely associated with George for years. We both lived in Arlington, Mass., where our families were neighbors and were in Course VI together, where he was a top student. We worked together in the laboratories and on solutions for electric power system problems. Also, we both played on the class baseball team (see *Technique,* 1909). After graduation he was an assistant in Professor Laws' measurements laboratory, spent some time with the Telluride Power Co. in Colorado and then was employed by the Western Electric Co. of New York. In 1926 he became an engineer with the International Telephone and Telegraph Co. of New York. He retired in 1940 but was recalled during World War II. He finally retired in 1956 and lived in Natick, Mass. He was always quiet and unassuming. At the Institute he stood at the top in the difficult Course VI and was an outstanding telephone engineer in the I.T.&T. Co.

Mrs. Dort wrote of the death of her husband **Joseph Cummings Dort,** at the age of 90, in January, 1976 in Keene, N.H. He was born in Keene in 1885. After he was graduated from the Institute he worked for the Water Resources Branch of the U.S. Geological Survey from 1910 to 1916 and then with the U.S. Forest Service. His work took him to Hawaii, and to Alaska to study the possibilities of hydroelectricity using the immense forests and of building bridges. He retired in 1948. He was a member of the American Society of Engineers and served on the Budget Committee of the United Church of Christ. He is survived by his wife Dara, a daughter Betty Austermand of Lexington, Mass., and three grandchildren. — **Chester L. Dawes,** Secretary, Pierce Hall, Harvard University, Cambridge, Mass. 02140

10

We regret to report the death, on February 13, 1976, of **Herbert S. Cleverdon,** who served as Class Secretary for 25 years. On account of poor health, he was unable to be with us at our 65th reunion last June, when he was elected Honorary Secretary. He received the S.B. degree in Architecture, specializing in structural design. Herb took an active part in class affairs while at the Institute (then located on the Boston side of the Charles River). Our Senior Portfolio indicates that, among other things, he was in the "chorus line" of the Tech Show for three years. In those days, the annual Tech Show was quite a production!

For several years, he served as consultant to a number of architects who did not employ structural designers in their own organizations. In 1926, he was a founding member of the Boston consulting engineering firm, Cleverdon, Varney, and Pike, which is still in operation. (Waldo F. Pike, '15, now retired, is the last surviving member of the three founders). For 20 years, Herb was a consulting structural engineer for colonial Williamsburg in Virginia.

Herb served in World War I as a captain and as a lieutenant colonel in World War II. During World War II, he was in Portland, Me. There he was responsible for the construction and inspection of coastal defense installations, such as radar towers, along the coast of Maine. He leaves his wife, Elizabeth (Weidel); a son, Robert; a daughter, Mrs. Stuart Baird; three sisters; and six grandchildren and five great-grandchildren.

In later issues of the *Review* we hope to include in our class notes a brief outline of the "retirement" activities of some of our classmates, whose health permits them to take part in civic affairs, to take interesting trips, or to engage in hobbies. We begin with our President, **Ralph Horne.**

Ralph spends part of each week at the office of Fay, Spofford & Thorndike, consulting engineers in Boston. He joined that company a few years after graduation from M.I.T. He is senior member of the Board of Directors of the organization. Until recently, he was a trustee of the Malden Public Library and a member of the library's building and grounds committee. He is an active member of three other building committees, for Malden Hospital, First National Bank of Malden, and Davenport Memorial Foundation of Malden. For diversion, he and his wife, Meta, are planning a short cruise to Nassau and Bermuda in late May with their daughter and her husband, to observe the wedding anniversaries of both couples. Those who attended any of our five-year reunions in the past quarter century will recall that Ralph and Meta always served as host and hostess at our cocktail parties. We bid them "bon voyage"! (We shall expect an account of their trip from Ralph later on.) — **John B. Babcock,** Secretary, 33 Richardson St., Portland, Me. 04103

11

Allston T. Cushing wrote: "After working many years as a Valuation Engineer for the United States Government I was retired in 1950 at age 60. I lived in Kansas City, Mo., until 1973, when I sold my home there and moved to John Knox Retirement Village in Lees Summit, Mo. My wife and I are enjoying life here, and both are in good health. Two of our three children have died. Our youngest, a son, is employed in Los Angeles." . . . **Harry R. Tisdale** said he is in very good health and drives his car every day.

Gordon B. Wilkes, Professor Emeritus at M.I.T., of East Orleans, Mass., died on February 16, 1976. He joined the staff of the Department of Physics at M.I.T. after graduation and was a professor there until 1934. He then transferred to the Department of Mechanical Engineering until his retirement in 1954. He is survived by his wife, Eloise; two sons, two brothers, and a sister. — *S.F.*

12

I only have sad news to report this month. **George L. Uman** of Los Angeles, Calif., died on February 20, 1976. He is survived by his wife Rose and three sons.

Albion Davis, of Wellesley, Mass., died on March 12, 1976. Mr. Davis graduated in mechanical engineering and later served as class agent for the Alumni Fund, and more recently as class president. Between 1928 and 1945 he was employed as comptroller and assistant treasurer for American Hide and Leather Co. of Boston, then president and general manager of Orange Food Products, Inc. between 1945 and 1949; and later was named New England Regional Accounting Executive for the Office of Price Stabilization in 1952. Mr. Davis was active in many community organizations, member of the American Society of Mechanical Engineers, and a former member of the Board of Directors of the Mass. Federation of Taxpayers Assn.

A letter from Mrs. Susan Babcock Clark told of the death of her father, **Henry A. Babcock,** of a massive heart attack on December 13, 1975.

Dr. Babcock was a nationally recognized author and lecturer on urban economics and appraising. After he received his bachelor's and master's degrees in mechanical engineering he taught at Northwestern University until World War I. After the war, he joined his father in the firm of William H. Babcock and Sons, Real Estate Consultants and Valuators, of Chicago. Henry Babcock worked for the recognition of appraisal as a profession and the American Society of Appraisers became his vehicle.

After the break-up of his firm during the depression, he settled in California with his wife and five daughters and there rebuilt his career. From his base in Los Angeles he valued nearly every type of property all over the continent. About 15 years ago he found that the total value involved in the appraisals he had done was almost $2 billion. That was before he valued the entire Union Pacific Railroad System.

Mr. Babcock had been a lecturer in finance at U.S.C. and U.C.L.A. He was a writer and a scholar from his first essay in 1926 "The Relation of Income to Value" to his last book, *Appraisal Principles and Procedures,* published in 1968. He remained prolific until the day of his death, loving his work and never intending to retire.

He is survived by his wife, Ruth; five daughters, one brother, 12 grandchildren and four great-grandchildren. — **Jonathan A. Noyes,** Acting Class Secretary, 320 Dunn St., Bryan, Tex. 77801

13

We have received several letters and notes from our classmates or their relatives: Patricia Hodgman writes: "My Father, **Stanley Hodgman,** is not well at this time, but I would like to continue his membership." . . . **Arthur Carpenter** writes: "I think it would be fine to have our 65th Reunion on campus. One day including the Alumni Luncheon would be adequate. I would certainly like to attend but it is of course too early now to know whether Irma and I will be able to." . . . **Stanley Parker** comments: "I'm sorry I can't make it this year. I am having 'leg' trouble and can't get around very well. My eyesight is still a bother too. Give my regards to everybody and best wishes to all my old classmates." . . . **Warren Gentner** writes: "Just returned from a three-day jaunt to my boyhood home town of Belfast, Maine, with a side trip to Bar Harbor, all through the courtesy of my daughter and her husband from Colorado who were visiting me at the time. If my health continues at its present level, I shall make every effort to attend our 65th Reunion."

Frank Achard adds: "I have just returned from my annual visit to my daughter, Ann, son Francis Jr., and niece Betsy and their respective broods. It was a dry run — all their families are teetotallers — but very pleasant. While in California last May, I saw my one and only great-grandson. At the moment I am busy putting together a meeting for the Boston Chapter of the Society for Technical Communication. The subject is 'Metrication' as expressed in S.I. units and forms. One of these days you will have your tires inflated to 200 K.P. or kilopascal instead of 28 psi. It's like learning a new language. Our exposure to the metric or CGS system was just a starter."

Warren Glancy hopes to attend our 65th reunion. . . . **Dave Nason** is undecided as always. . . . **Herbert Shaw** states: "No news, just the regular lazy life." . . . From Jane and **Henry Glidden:** "I feel that the 65th Reunion should be on campus for one day, including the Alumni Luncheon. Jane and I enjoyed a week in New Hampshire, driving through the most colorful fall foliage we have ever seen. Lake and Mt. Chocorura — always beautiful — were superb in their brilliant reds, greens and yellows. A dusting of snow on Mt. Washington one morning was an added feature. By the way, I hope that parking space can be reserved for our cars in back of Kresge, or some equally convenient place." . . . From Bunny and **Bion Pierce:** "We will be at the reunion and prefer three or two days, including the Alumni Luncheon."

A note was received from Rosemarie Synek of 5300 N.W. Loop 410 - #1502, San Antonio, Tex. "It is with sadness that I notify you of the death of my father, **Arnold Spencer Wahl,** 9 E. Goethe St., Chicago, Ill. 60610. He passed away on November 18, 1975. He leaves his widow, Rosemary, a son Arnold C. Wahl, and a daughter, Rosemarie Wahl Synek, '56; and by a previous marriage, two sons, Robert A. Wahl and William Wahl, and a daughter, Elizabeth Wahl Colvin. My father was born in 1892 in Chicago, Ill. Should you wish any more information, please write to me. (He was considered a world-authority on the technology of brewing, and was president of the Wahl Institute.)"

As it stands now, we shall probably not join in the 1976 Alumni Day festivities. — **George Philip Capen,** Secretary and Treasurer; **Rosalind R. Capen,** Assistant Secretary, Granite Point Road, Biddeford, Maine 04005

14

A late-February letter from **Hibbard Busby** told of the arrival of spring in Texas. That was good news for us in the north. Bus enclosed a picture of "us three": himself, his wife, and their dog, all looking good.

A paragraph in a letter from **Ray MacCart** shows that at least some things have changed for the better in the past 60-odd years. "My last year I specialized in refrigeration, and it so happened that the president of the Quincy Market Cold Storage Co. in Boston, who was an M.I.T. man, wanted to upgrade his personnel technically, so I was offered a job and was assigned to the chief operating engineer. I accepted the job without negotiating pay because I wanted to stay in Boston for a while and jobs were scarce. When I got my first pay envelope it had $9.00 in it. I complained to the chief and he said that he would have paid me more if I didn't have so many degrees, but that I had a lot to unlearn."

Ralph Salisbury's daughter Barbara (Mrs. Anibal Buitron) wrote in February that her father retired from the Corps of Engineers in 1953 and then lived in California, first in Grass Valley and then at Sunset Beach, near Watsonville, where he died. He was active in the Veterans of World War I and in the Association of Retired Government Employees. Although he developed a serious illness during his later years, he remained active and vigorous until the last month, and even then was able to stay in his home. His wife died in 1972, and his only son, Ralph, Jr., in 1955. Besides his daughter, he left a brother, Laurence, in Guilford, Conn. — **Charles H. Chatfield,** Secretary, 177 Steele Rd., West Hartford, Conn. 06119

15

Our scouts report that these "snowbirds" spent the winter in Florida: **Jack Dalton,** Winter Park; **Clive Lacy,** Orlando; **Max Woythaler,** Clearwater; **Wayne Bradley,** Miami; **Larry Landers,** Hollywood; **Jim Tobey,** Palm Beach. **Whit Brown, John Homan, Bob Mitchell,** and **Fred Vogel** have retired to live down there.

Phil Alger writes, "I am making a cash donation to M.I.T. instead of leaving it in my will. I'd rather be a live donor than a dead donor." (I agree.) Phil has been invited by the sponsors of the Tesla symposium in Zagreb, Yugoslavia, to present a paper extolling the role and results of Tesla's invention of the induction motor in 1888. Tesla is the Edison of the Yugoslavs, so they are celebrating his 120th birthday in July. Phil reports, "As they offer to pay my way from New York, I cannot well refuse the invitation. I plan to fly from Boston, with my grandson Monty, to Zurich on July 1. Then on to Zagreb and London. Next we plan to visit my friend, Professor Shepherd, in Bradford, and then go to Edinburgh, flying home about July 20."

Bill Brackett has enjoyed corresponding with Joyce Brado, our Class Agent. She is doing an outstanding job for us, and writes an interesting personal thank-you letter to everyone who contributes to the Alumni Fund. We appreciate her loyalty and interest and are very lucky to have her on the job.

Frank Boynton is living comfortably in an excellent nursing home in L.A. Good for him. . . . **Alton** (The Woof) **Cook** expected to visit his family in L.A. the end of March; upon his return he will begin nursing those famous roses of his. He plans to be here for our 61st Reunion on Friday, June 4.

Bob Welles always writes an interesting letter: "Long time since I last dropped you a line. I hope the world is treating you right and that you are in tolerably good health. I wonder how many of the class are profiting from the bull market on the stock exchange. No doubt about the market being on the way up just now, but the big question is what will happen later on when the dollar goes to pot. At the rate we are spending it's going to do just what the French franc and the German mark did some years ago. But in the meantime, bull market. Queer situation. For Christmas we went to the banks of Lake Mead (Colorado River) and barbecued our turkey outdoors. We are planning a trip East this summer, and hope to see, among other things, the parade of square riggers in New York harbor July 4."

Ralph V. Tiffany died in Winsted, Conn., on March 10. He was Selectman there from 1935 to 1937, G.O.P. State Representative in 1933, Trustee of the Gilbert School from 1938 to 1968, a corporator of the Mechanics Savings Bank and the Winsted Saving Bank, a former director of the Citizen Printing Co., and a director and board president of the former Litchfield County Hospital.

He was President of Tiffany and Pickett Co., established by his father in 1904, from 1940 to 1965 when he retired.

An early radio enthusiast, he built a number of radios during the 1920s. He also invented an electronic door-opener for his garage before such openers were in general use.

Ralph was always a loyal and generous supporter of all class and alumni activities. The sympathy of our class goes to his family.

I hope to see many of you here for our 61st Reunion Cocktail Party at the M.I.T. Faculty Club, 50 Memorial Dr., Cambridge, at 4 o'clock, Friday, June 4. — **Azel W.**

Mack, Secretary, 100 Memorial Dr., Cambridge, Mass. 02142

16

For several weeks, we have been receiving responses to our questionnaire about attendance at our 60th reunion. They have been very encouraging. So far, the following are hoping to attend: **Bingers, Camp, Carrs, Coleman, Comiskeys, Connollys, Crowell** with son Bruce and Bruce's wife, **Duffs, Ellicott, Fairfields, Fletchers, Forsyths, Gordon, Guethings, Holland, Lawrances, McCarthys, Mueser, Pattee, Pattens, Pearson, Reeds, Robertsons, Shepards, Sullys, Ullians, Youngs, Warshaw, Websters.**

Francis Stern wrote, "I have a cataract operation on May 13. If all goes well, the doctor may let us come, but we won't know until the last moment. Let's hope I can make it. I surely want to!" . . . **Theron Curtis** writes, "I was pleased to see the name of George Crowell and his son, Bruce, listed as present at your meeting of January 21. From 1912 to 1916, in the old buildings in Boston, "Gira" Crowell, Bob Crosby, and I were close friends in the M.E. Dept." As for attendance at 60th, Theron says, "Possibly." . . . **Allen Pettee** is pleased with the progress Helen is making. Her condition now "will not permit travel. Wish we could be with you." . . . **Willard Brown** can't make it and sent this note: "My very best to my many friends who will be there for our reunion. Over the years we sure got to know each other very well." **Este Fisher** responded, "At present age (84) and somewhat enfeebled condition, I just don't feel that I can make it, charming though it all sounds." . . . **Rudi Gruber** will be in Germany for a family reunion when we are at Chatham. He wrote, "I deeply regret being unable to attend the reunion. God bless your good work." . . . **Ed Jenkins** responded, "What delightful fantasies you arouse but my sober answer must be 'no'." From **Dick Knowland,** "Too far for us." . . . **Frank Bucknam,** "When I attended our 50th reunion I spent some time with my sister in Swampscott, Mass. She since died and I have made my last trip east. It tires me out too much. We have been here and like Auburn, Calif., (God's Country) for over 17 years and I don't like to leave home any more." . . . **George Maverick,** "I hate to say it because Ruth and I had such a wonderful fun time the 50th and thereafter but it now looks as though we can't get away from the doctors."

Art Caldwell sent a longer message: "Words cannot adequately express my keen disappointment in telling you not to count on me for any of the events relating to our 60th reunion. . . The principal trouble is that on November 16, 1974, while in N.Y.C. I blacked out due to a mini-stroke. . . This can recur at anytime without warning, or never. . . I use a cane to steady my gait and must be careful not to fall. All in all I was lucky; it could have been much worse. Under all circumstances, the prudent thing for me is to remain here and take no chances. The decision is a hard one to make, especially so as I also missed our 50th due to a serious illness in 1961. Give my best to all and particularly to any surviving Sigma Tausers." . . . **Will Wylde,** "It's a great disappointment for me but I cannot make it." . . . Gretchen and **John Gore** have been coming to annual reunions for years and for each of the last two reunions Gretchen has endured great handicaps to be with us. John writes, "My wife would not be able to make it this year. We usually go to Rockport, Mass., in October. We had to pass this up last fall." They have added a great deal to everyone's pleasure at our reunions and will be missed. . . . **Walter Metz,** "Sorry I will not be back this year. Maybe next." That's the spirit, Walter. . . . From **Walter Wolfe,** "Sorry, but I would like to make a small donation to help with mailing costs." . . . **Hank Smith,** "This is one I would hate to miss, and I may be able to make a deal with some other M.I.T. man in the vicinity." . . . Another big disappointment is that Grace and **Harold Dodge** will not be coming to our 60th. Harold is doing well but his doctor doesn't want him to travel. . . Many others have responded "no" without comment and while we are sorry that they cannot attend it sure is nice to hear from them.

For the last time, then, we will celebrate our 60th reunion at the Chatham Bar Inn on Cape Cod in Chatham, Mass., on June 1-3, Tuesday to Thursday. On Thursday night, June 3, many of us will attend the "M.I.T. Night at the Pops" at Symphony Hall in Boston. On Friday, June 4, M.I.T. schedules a variety of interesting and informative programs as well as the alumni luncheon on what is now known as "Technology Day," formerly known as Alumni Day. As we write this in March, we have not determined what, if any special 1916 activities will be scheduled at Tech on Thursday night and Friday. This is a rare event in anyone's lifetime. We want to share it with all of our classmates and are ready to do anything that we can to assist those who want to come. We'll be happy to see you even if you can only make it for an hour or so.

Victor Y. Dunbar wrote, "M.I.T. did not see much of me as I was there in Course IV only one year after graduating from Dartmouth College in June 1913. Although not a grad of M.I.T. the class of 1916 seemed to adopt me some time after World War I. **Leonard Stone** became a real friend as he wrote me a pleasant welcome to the 1916 alumni group. Soon we became real friends as we had a common interest in Lake Winnipesaukee, he in an island near Bear Island and I in Little Bear island nearby. I have not met Leonard I am sorry to say, but I have phoned him while passing through New York City. Unfortunately Leonard had to leave us.

"Later Harold Dodge wrote me and we have a common bond, we both have a love for the State of Maine. Also each of us has had a stroke. I am sure that all in 1916 hope that he is getting stronger and soon will resume as Class Secretary."

Clint Carpenter died on March 15, 1976. We will print the details next issue.

Again, we look forward to your cards and letters. Keep breathing and keep writing. — **Ralph A. Fletcher,** Acting Secretary, West Chelmsford, Mass. 01863

17

Three students now share scholarship aid from the 1917 Aldrin Scholarship Fund. Recent notes have quoted letters from Michael Solis, '77, and Alan Glombicki, '77. Now there is one from Paul A. Lagace, '78, a student in the Aeronautics and Astronautics course.

"Lewiston, Me., is my home with my family of three. I have had two desires: to go to M.I.T. and to be involved in N.A.S.A. After attending local schools, I entered a private Jesuit high school in Portland, 40 miles from home. At Cheverus High I was able to take advanced calculus and attend a class at the University of Maine in Portland.

"Coming to M.I.T. was a big step for me, but after two months everything began to fall in place. I was always interested in the space program and looked into the Aeronautics and Astronautics Department early in my freshman year; I decided to major for Aeronautics and Astronautics midway through my second year.

"In high school I was on debating team, state champions in 1974; captain of the math team; editor of the school paper; and involved in student government. Now, unfortunately, my academic commitments and need for money have limited my activities. I average a 54-hour course load; and I work on the student dining staff, the desk staff and referee intramural games; I am looking into the Undergraduate Research Opportunities Project. I am active in MacGregor House government, and play on house teams. My saxophone, which I have played for ten years, gets a little sneaked-in attention.

"Please express my gratitude to all class members; I hope to be able to meet you some day."

"AP" Sullivan's serious hobby is the maintenance of some 200 antique clocks. But after two moves, one recent, what's become of the clocks? AP writes, "A few years ago, I decided to preside over the collection's dissolution rather than wait for some auctioneer to do it after I was gone. Accordingly, many of the clocks are now in the households of my two sons, who are clock fanciers but not horologists. Others were given to friends and relatives who admired them. After keeping about ten for my own home, the rest were given to younger fellow collectors who I felt would give them good homes. Thus I hope everyone, including the clocks, has been made happier." AP started the year poorly, with an operation as the result of a routine physical examination; he recommends regular exams for us old fellows. He has come along nicely.

We've mentioned Chi Kuan Wu, '71, grandson of **P. Y. Hu,** who has received student aid from a 1917 fund. Recalling the first conversation with him in 1967 when his English was so limited, his latest letter is amazing, as is his progress — S.B. and M.S. in nuclear engineering. "Since leaving M.I.T., I have been working at Valley Forge Space Center of General Electric in suburban Philadelphia. I went to Singapore for a month in 1975, to visit my grandfather, Hu Po-quan (our P. Y. Hu), who had just suffered a stroke. He had a second stroke in June, and his condition headed down steadily. He passed away on October 21, at the age of 87.

"My grandfather came to M.I.T. on a Chinese government scholarship. He studied metallurgy and petroleum engineering, and devoted the best part of his life to establishing heavy industry in China. He erected one of the earliest blast furnace plants in the country and was appointed Director of Mines, Ministry of Industries, in

1928. Later he served in other important educational and technical positions, and represented China in a number of international conferences. He was president of Chinese Institute of Mining Engineers and vice president of Chinese Institute of Engineers. His last 20 years were spent in Singapore and Malaya. After leaving Nanyang University as Dean of Engineering and Science, he taught at University of Malaya.

"Looking back I can proudly say my grandfather stands among the first generation of western-educated Chinese who selflessly dedicated themselves to industrializing their country. Their collective efforts laid the foundation for modern Chinese industry."

Word of **Haig Solakian**'s death came too late for more than a mention in the last notes. Along with **Rudy Beaver** and P. Y. Hu, he was a special person in the class: foreign born, limited English to begin with, these three made genuine contributions to their fields and to M.I.T. Haig was President of Bellis-Crown Co. of Branford, Conn. During World War I, he developed the stereoscopic range finder adopted by the War Department. At the Bureau of Standards, his research on the cause and prevention of corrosion in aluminum alloys helped to solve the mystery of the crash of the Shanandoah Dirigible. He was granted numerous patents, was a contributor to technical journals, and was a member of the American Society of Metals. He is listed in "Who's Who in American Men of Science." We were all happy to see Haig, his wife, Rose, and their two daughters at our 58th reunion last October.

Susan Williams **Lunn** died on March 17. She had been ill for a short time. Our deep sympathy goes out to our President, **Al,** and his family.

A pictorial history, *M.I.T. in Perspective* by Francis E. Wylie, was recently published by Little, Brown Co. It is a fascinating and impressive chronicle. In it, we find a liberal sprinkling of 1917 men of note who have contributed significantly to the accomplishments and pioneering leadership of the Institute.

Noah Gokey says, "We are just rocking along, listening to our arteries harden in Virginia Beach. No change in Alline's condition, I'm sorry to say."

Harold Sterner, architect and artist, died on March 12 in New York City. His architectural work ranged from remodeling Amster Yard on East 49th St., once a terminal for the Boston stagecoach and now a city landmark, to designing the Hilton Hotel in St. Thomas, Virgin Islands. He has exhibited paintings and drawings of ships, seascapes, landscapes, and figures, as well as architectural renderings.

Other deaths recorded with regret are **George E. Walker** at Palm Beach, Fla., on December 25, 1975; and **James G. McDougall** at Marblehead, Mass., on March 3. — **Stanley C. Dunning,** Secretary, 6 Jason St., Arlington, Mass. 02174; **Richard O. Loengard,** Assistant Secretary, 21 East 87th St., New York, N.Y.

18

As one of the workers on the $225 million M.I.T. Leadership Campaign I am very much impressed with the great diversity of M.I.T. as a university. Not many of us are familiar with such programs at our Alma Mater as Political Science Department, Center for Policy Alternatives, Center for Transportation Studies, Center for International Studies, Joint Center for Urban Studies.

John W. Kilduff, '18, (center) is presented a plaque for his service to the Amesbury community from Industrial Development Commission Vice Chairman Leo Mills (left) and Chairman Herbert E. McDonald (right).

John W. Kilduff, vice president and general manager of Amesbury Metal Products Inc., was honored as Amesbury Industry's "man of the year" by the Industrial Development Commission. He has been with the company 50 years and has been president 16 years. The award was made for "his persistent efforts to protect jobs and maintain productive activity." He lives in Rye, N.H., and is married to the former Eleanor Wood.

I have been especially close to John for these many years — and no one deserves better than he this accolade from his fellow citizens.

Selma and I spent a most pleasurable evening with Jean and **Julie Avery** at their charming home. About a year ago he was honored at a Julian M. Avery luncheon given by M.I.T. because of his contribution to the technology of producing steel. In a very few months we will receive news of his process for producing pure magnesium at a lower cost.

Within the last few days came this letter from **Wingate Rollins:** "Did have some fine trips last year and the year before. In 1974 went out to visit the four main islands in Hawaii, stopping off in California on the way back. But 1975 ended with a sad note. After just returning from our third trip to the West, my wife, Sallie, was taken sick a day or two after we returned, with a ruptured esophagus, which could not be helped because of a serious liver condition. She passed away on October 25 after being in the intensive care ward at the Milton Hospital for two days. Prior to this third trip in 1975 we did go to Nantucket and later on, a nice motor trip through Vermont to the Canadian border and back through New Hampshire. Right now, I am busy helping to plan our 60th Reunion, Harvard Class of 1916, coming up in mid-June. Many thanks for your interest in my doings!"

I had a long newsy letter from **Herb Larner** — He is an extensive traveler and a great story teller but space doesn't permit publication of his colorful account of adventures in and near Berchtesgaden, Germany. Interested readers may have a copy from the editors of the *Review*.

I am very happy to report a nice telephone conversation with Hazel **Fletcher** — she reports that **Sax** is how home and is slowly improving. . . . I can also report that **Julie Howe** has returned to his early love and is now taking violin lessons. He reports he now practices without closing the door. Do all great men have a violin in their past?

I record the passing of **George B. Cutts** of Brookline, Mass., on March 11, 1976. He attended M.I.T. with our class but left the Institute to enlist in 1916. He is survived by his wife, Priscilla Whipple, two sons and five grandchildren. — **Max Seltzer,** Secretary, 60 Longwood Ave., Brookline, Mass. 02146

19

A nice letter from **Francis A. Weiskittel:** "Salutations and grateful appreciation to Gene Smoley, the 1919's loyal secretary who keeps us informed of the 'Goings and Comings' of old friends and acquaintances. How blessed are those who are accompanied by their wives, whereas I have been a widower for 18 years. I drove to Disney World with my retarded son (30 years old), then to Key West and back through Ft. Lauderdale, Vero Beach, Outer Banks of N.C., Williamsburg, Va., and Fairfax, Va. with my married daughter there. Phoned but did not reach Gene Smoley at Delray Beach. My other son (29 years old) is still pursuing classic languages at Corpus Christi College, Oxford, England."

Word has reached us of the death of **Alfred G. Hoffman** on January 3, 1976 at Wasco, Ill. He worked for the General Electric Co. in Chicago as an application engineer for 41 years. He leaves his wife Rita, nine grandchildren and two great-grandchildren.

A note from **Ervin M. Kenison** states, "Still playing duplicate bridge and

shuffleboard. Live in Florida all year." . . . **George R. Bond, Jr.** writes, "I keep very busy with Y.M.C.A., Boy Scouts, Church activities, Kiwanis, etc. Also do quite a bit of traveling. Visited Switzerland, Italy, Austria, and Germany last year and plan to visit Ireland, Scotland, and England this April." . . . A note from **Edward E. Scofield** — "Am reasonably well; still happily married to my first choice; have managed so far to cope with inflation and avoid relief; keep busy with accounting work and household emergencies; have fine set of offspring; manage to see dear friends scattered from B.C. to Florida; still have driver's license but avoid night driving if possible, and wish all a good 1976."

Your secretary sees **Nelson Bond** here in Delray Beach. I had lunch with **Donald D. Way** on March 4, and **Marshall Balfour** on January 31. Both these classmates are doing well. Also had calls from **Charles Drew** from Biscayne Bay on March 6. Chuck is honorary director of Y.M.C.A. and the Society for the Blind in Minneapolis, Minn. He was in Europe in the spring and Scandinavia in the fall of 1975, and on the *Nordic Prince* recently completed a 14-day cruise in the Caribbean with his wife. . . . **James Reis** phoned from the airport at W. Palm Beach on his way back from a 44-day trip to South America with his sister, and says he is in tip-top condition.

Just received word from **Don Way** of the sad news of the death of **Marshall Balfour.** The *New York Times* of March 23 states as follows: "Dr. Marshall C. Balfour, a retired staff member of the Rockefeller Foundation who had been active in population control died Saturday, March 20, in Chapel Hill where he lived. He was 79 years old. He joined the foundation in 1926 and devoted many years to malaria control programs in the U.S., Greece, China and India. He returned to the U.S. in 1947 for graduate study in Public Health and began work in 1949 on a program of population studies for the foundation."

Your secretary is cruising the Greek Islands in May and will be in Chautauqua N.Y., 38 Peck Ave., phone 716-357-2431 during July and August. — **E. R. Smoley,** Secretary, 50 East Rd., Delray Beach, Fla. 33444 (Phone 305-278-4537)

20

Good news from Florida. **Bat Thresher,** who served as Director of Admissions at the Institute for 25 years, is one of 15 persons in the nation to receive the Edward S. Noyes Award for outstanding service to the College Entrance Examination Board. The award was established to observe the Board's 75th anniversary. It recognizes outstanding service through long and active involvement in C.E.E.B. programs. Bat, the author of "College Admissions and the Public Interest," has served on many C.E.E.B. committees and as chairman of several, and he was C.E.E.B. Vice Chairman for several years and its Chairman for several more. He and Irene live in Cocoa Beach.

Another Floridian, this one from the West Coast: **Harry Bower** of Bradenton writes that he has enjoyed 20 years of retirement. His letter was inspired by the picture of our 55th in the January issue.

Due to the thoughtfulness of **Cac Clarke,** Secretary Emeritus of 1921, I received word of the death of Esther **Glassett,** widow of our beloved **Al,** in Pompano Beach. Many of you will remember Esther from our 50th. What a delightful and charming person she was!

As the time approaches for Technology Day, we are hoping to welcome a goodly number of the Class so we can discuss plans for our 60th. 1980 is a year to look forward to. Until then, the very best of health and spirits. — **Harold Bugbee,** Secretary, 21 Everell Rd., Winchester, Mass. 01890

21

Another long and welcome letter came in from **Grant Miner:** "Just finished a stint as a juror in a civil case in San Jose. It took all of nine days and really ruined the better part of three weeks for me and Marianne. She went down with me every day and was laughingly known by the clerk of the court as the 14th juror. We had lunch together every day and at a different hostelry — went into the hole because our bar bill always exceeded my daily stipend as a juror. I was chosen as foreman of the jury. We deliberated for about three and a half hours, not to make it look too easy, and found for the plaintiff for the full amount of the suit. Now, I've done my civic duty — no more for three years.

"Had a nice call from **James Stewart Parsons.** He gave me 100 to 1 odds I couldn't guess who was calling. His voice hadn't changed in 55 years. We're going to see him and his wife Helga, the Norske Flicka, on March 22.

"Had a letter yesterday from David Starkweather, son of John Burr Starkweather, '22, who is really a '21 man. John and his wife Ellen are celebrating their 50th on March 6 (congratulations!) My work with the Zenitaka Co. has been enlarged; I'm now making monthly reports to the head office in Osaka. They're interested in earthquakes (prediction, causes, prevention, structural design), energy of all kinds, lasers, new construction materials and methods. They raised my monthly stipend 50 per cent. Marianne and I are still taking our walks more or less regularly every day, doing all our own gardening and lawn work which is keeping us both fit and in good condition."

Alfred Balsley writes: "Recently I moved from Pebble Beach to 319 Maple Ave., Reidsville, N.C. 27320. Best wishes to all members of the class." . . . **Williston Wirt** wrote in December: "Your letter was forwarded to our present address in Kamuela, Hawaii. I am here for three months filling the Imiola pulpit while the church looks for a permanent pastor. We served in Hawaii ten years ago on Oahu. That place is just as overbusy as Hollywood. We are on the big island in a small village on the Parker Ranch. It is so old-fashioned that people don't lock doors or remove car keys. We visited the volcano but it didn't fizzle or pop for us. A warm aloha from the land of leis and earthquakes."

Sam Lunden wrote that he and Leila drove to San Diego in February to attend a three-day seminar on "Architecture for Justice." He phoned **Ed Farrand,** our Estate Secretary but got no answer. He did reach **Gus Kinzel** and paid him a short visit. He reports that Gus is in robust health, active in many fields and has a very interesting home high above La Jolla bay. A lazer he sails was stowed on his patio.

Betty and I left home late in January to spend five weeks in Sarasota, and arrived to find three of our classmates ill or recovering from illness. **Herb Kaufmann** had had a bout with pneumonia the week before which didn't require hospitalization and now complained of feeling well again. . . . **Whit Spaulding** was in bed with a high temperature and a strange bug that responded not to antibiotics but to aspirin. . . . And **Larcom Randall** had to be hospitalized because his heart was kicking up again. Poor Larc was in and out of the hospital while we were in Sarasota but I finally saw him one morning when I walked up the beach and dropped in to chat with him and Katherine for 20 minutes. He was in good spirits but feeling pretty weak.

We joined forces with Claudia and **Josh Crosby** several times and they hosted a cocktail party late in February which included Millie and Herb Kaufmann, Beth and Whit Spaulding, Graciela and **Helier Rodriguez,** Helga and **Jim Parsons** and the **Haywards**. Alice (Mrs. **Robert**) **Felsenthal** was hostess one evening for cocktails and the Kaufmanns were our hosts at dinner and a delightful luncheon looking out over their beautiful cove.

Helen and **Bob Miller** spent two weeks at Marco Island, Fla.; and while there **Phil Coffin** gave them the 25-cent tour of Naples and then set up a luncheon date which included Margaret and **Dick Windisch,** Helen and **Mich Bawden,** Marion and **Phil Payson** and Olive and **Herb Gwynne.** Mich Bawden gets around in a wheel-chair these days but Bob Miller says he is in fine spirits and was delighted to get to the luncheon. When the Millers left Marco Island, they drove up to Sarasota and Josh Crosby arranged a luncheon date which included the Millers, Parsons, Spauldings, Haywards, and himself. I learned from Josh that **Fred Olson** of El Cerrito, Calif., was in Florida for a month's stay at Sanibel Island. Fred and Josh worked together years ago at Hood Rubber Co.

Jim Parsons tells me he had a heart pacemaker installed, feels wonderful, and recommends it for shortness of breath and a sluggish heart. He and Helga were recently back from a Caribbean trip, were planning to go to the Mexican Fiesta, and in July, are taking a boat trip around the British Isles, into the Norwegian fiords, and then on to Sweden and Denmark.

I am sorry to report five deaths this month: Admiral **Andrew I. McKee** of New London, Conn., on January 24, 1976; General **Daniel Noce** of Sperryville, Va., on February 17, 1976; **R. Brace P. Crawford** of Oxnard, Calif., on August 7, 1975; Colonel **Holland L. Robb** of Sun City, Ariz., on October 18, 1975; and **Elmer W. Davis** of Rochester, N.Y., in November, 1975.

Admiral McKee graduated from Annapolis in 1917 and got his master's degree at M.I.T. in 1921. He served in the Navy construction corps in both World Wars and was in charge of submarine design at the U.S. Naval Bureau of Construction and Repair. After retirement from the Navy, he joined the Electric Boat Div., General Dynamics Corp., and served as Vice President and Director of Research and Design. He played a major role in the rescue operation of the submarine *Squalus*, which went down off New Hampshire in May, 1939.

General Noce graduated from West Point in 1917 and got an S.B. in Civil Engineering

at M.I.T. in 1921. He served in France in World War I and prior to World War II was engineering officer in charge of harbor defense of Manila Bay and the fortification of Corregidor. At the outbreak of World War II he returned to the U.S. to organize and head the engineer amphibian command which trained 50,000 soldiers for amphibious operations. He was sent to Europe in 1944 as assistant chief of staff and director of plans and operations for all Allied forces in the Mediterranean theater. After the war General Noce was chief of staff of the European command in Germany.

Brace Crawford prepared for M.I.T. at the University of Georgia. He was sales manager of Buildice Co. of Chicago during the 1940s, Inspector of Naval Material in Los Angeles in the early 1950s and in recent years was working on smog problems in the Los Angeles basin.

Colonel Robb graduated from West Point in 1916, served in World Wars I and II and in Korea. His fields were construction and troop commands. After finishing his army career in 1953, he was active in Republican party politics in North Carolina and ran unsuccessfully for Congressman. He traveled extensively all around the globe in his retirement years.

Elmer Davis prepared for M.I.T. at a high school in Hartford, Conn.; worked for a number of concerns until 1936, and in subsequent years was president of Elmer W. Davis Inc. (building materials).

The sympathy of the class is extended to the families of these classmates.

Each of you received the questionnaire concerning the location for our 55th Reunion. As of this moment (March) the returns favor staying the whole time in Cambridge. Hope to see you there! — **Sumner Hayward,** Secretary, 224 Richards Rd., Ridgewood, N.J. 07450; **Josiah D. Crosby,** Assistant Secretary for Florida, 3310 Sheffield Cir., Sarasota, Fla. 33580; **Samuel E. Lunden,** Assistant Secretary for California, Lunden and Johnson, 452 South Spring St., Los Angeles, Calif. 90013

22

Belated congratulations to Mary and **Oscar Horovitz,** who celebrated their 50th Wedding Anniversary on February 21 in Pompano Beach. Oscar is a famous amateur cinematographer who has received many awards for his work. Here's hoping that his golf at Palm Aire has been as good as his pictures. . . . **William B. Cooper** and his wife, of Albany, announced the marriage of their daughter, Polly, to John E. Wild of Boston. . . . **William B. Elmer** and Cathleen, of Andover, accompanied their son, Edward, on an inspection tour of eastern colleges, including M.I.T. . . . they were impressed by the strange and informal personal appearance of the students.

William H. Mueser, of New York, is retiring from the partnership of Mueser, Rutledge, Wentworth & Johnston. Bill has been active in the heavy construction field over 50 years. He is outstanding in the design and supervision of a variety of projects, including deep building foundations and marine projects, highway subsurface engineering, underpinning, and subway work. He graduated from M.I.T. in civil engineering, then took graduate work at the Technische Hochschule in Berlin. Bill joined the

Mary and Oscar Horovitz, '22, celebrating their 50th wedding anniversary.

staff of Moran, Maurice & Proctor in 1923 and has spent more than 52 years with them prior to retirement. He became a partner in 1935. Bill received the Moles Award for outstanding achievements in construction in 1975 and the Metropolitan Section A.S.C.E. Civil Engineer of the Year Award in 1959. This year, the Construction Division of the A.S.C.E. honored him as one of the top U.S. construction men of the past 50 years.

Mrs. **Martha** (Eiseman) **Munzer** of Mamaroneck, N.Y., is teaching a course in Community Development at Mamaroneck High School. Martha is a member of the Conservation Advisory Commission, Town of Mamaroneck Land Use Committee, and the League of Women Voters. . . . **John Skelton Williams** of Richmond, Va., recently attained his "Certified Life Underwriters" diploma after five years of study. At age 78 John is possibly one of the oldest ever to win C.L.U. John is still active at tennis and summers at Cape Cod, Mass. . . . A brief note from **Charles M. Welling** of North Bennington, Vt., was submitted by his wife stating that he is in a nursing home. . . . **Wilfrid M. Thomson** (Tommy) of Corona del Mar, Calif., writes that his Christmas with his daughter, Mrs. Larry Fownes in Vero Beach, had to be delayed until Easter because his wife, Janet injured her ankle and knee.

Ralph Shaw, '21, is President of Pedrick Tool and Foundry in Philadelphia. His daughter, Mary, is Vice President and General Manager. Ralph was originally in railroading and then in Alabama Mills where he worked in fog vision with infra-red light. He and David Grimes tried it with radio and produced radar. Other Shaw contributions include welding of special steel and the process for preventing a welded ship from breaking in two. Ralph also experimented with autochrome plates and actinic light before Kodachrome.

The sympathy of our class is extended to the family of **Albert L. Sargent,** of Malden, Mass., who died in January after a long illness. For the past 40 years, Al was employed in the industrial engineering and insulation field. He was an engineering consultant for the Philip Carey Co. and the Eastern Refractories Co., and retired January 1, 1976. Al was a member of the Malden Historical Society and the First Parish Universalist Church in Malden. He is survived by his wife, Frances (Wilson); a son, a daughter, and four grandchildren.

We are sorry to hear of the passing of **Fay S. Lincoln,** of Avondale, Penn., who was our Class Photographer for many years. He was the founder and President of Corinthian Publications, who manufactured greeting cards of Williamsburg, Charleston, and the Islands. We will all miss his pleasant and friendly greetings.

We also send sympathy to the families of **E. Randolph Haigh** of Boca Raton, Fla.; and **Walter T. Kirley** of Waltham, Mass.

We are now off to South America to spread the good news about Buffalo and western New York. Hope to see you all on June 4 at the Alumni Day Luncheon — **Whitworth Ferguson,** Secretary, 333 Ellicott St., Buffalo, N.Y. 14203; **Oscar Horovitz,** Assistant Secretary, 3001 South Course Dr., Pompano Beach, Fla. 33060

23

William J. Boesch, Associate Technical Director, Special Metals-Allegheny Ludlum Industries Co., New Hartford, N.Y., was among the 41 fellows of the American Society for Metals honored at the A.S.M. annual reception and dinner on November 11. . . . **Scott van Emon Taylor,** who holds a number of patents for mechanical devices with the Cleveland Pneumatic Tool Co., has recently been granted another patent pertaining to a hydraulic transmission system. . . . **Lyman L. Tremaine,** former tennis star of 1923, lived at the wrong time, which is the only reason why he never received $100,000 for a tennis match. When he was playing, he beat all challengers on the Westfield and M.I.T. courts. He and his wife, Helen, have just returned from a visit in Virginia with Mr. and Mrs. Roland N. Black, '24.

Samuel L. Williams roomed with **Uncas A. Whitaker** for several years and reports that Uncas had a pronounced flair for inventing. On one occasion, Uncas rigged up a system to close the bedroom window on cold nights. The system was operated by a candle which, when burned low, triggered the lever to shut the window. The system failed one windy night when the breeze blew out the candle. Shortly thereafter the pair was requested to find another accommodation. . . . **Arthur R. Belyea** who was named citizen of the year for Old Saybrook, Conn., a few years ago, has become recognized as an outstanding historian for several articles on the development of this historic town.

Leo Poor writes that he is preparing a report for Bacon and Davis on Algerian Railways. He has made three trips to Algeria, but has had no fun — not even Paris stopovers. . . . The press reports that **Miles Pennybacker** who served on the Business Advisory Committee to President Truman's Council was named by Gloria Schaffer to serve on her campaign treasury committee. She wants the Democratic nomination to run for the U.S. Senate.

Mrs. **Uncas A. Whitaker** was elected a Life Trustee of the Health Sciences Fund. Both she and her deceased husband shared in developing and teaching research in the life sciences and medicine at M.I.T. The Whitaker Building contains a plaque acknowledging their endowment. . . . **John S. Keenan** who retired as Vice President of Canadian General Electric Co. in 1965 makes his winter home at New Smyrna Beach, Fla.

Douglas K. Severn died at the Backus Hospital last November. He had been president and treasurer of the Van Tassel Leather Co. from 1931 to 1975.

Roy George Rincliffe, who retired in 1969 as Chairman of the Board of the

Philadelphia Electric Co., died on February 3 in Fort Lauderdale, Fla. He was a native of Sandusky, Ohio, and was graduated from Yale in 1921. After service in World War I, he took an M.S. degree in Chemical Engineering at M.I.T. He became nationally known for his achievement of improved generating technology and for leadership in the nuclear power program of the United States. He held honorary degrees from Widener College, Villanova College, St. Joseph's College, Drexel University, and Thomas Jefferson University. Roy is survived by his wife, the former Eulalia C. Peterson, three daughters, and 12 grandchildren.

Alex Taller, sculptor and former assistant dean of administration at Hunter College, passed away on December 6, 1975 in Palm Beach, Fla. After his retirement he devoted himself to sculpting, and fashioned his work from such raw materials as whalebones, turtle shells, corals, wormwood, driftwood, and coconuts. His works were exhibited in several shows in New York. He leaves his wife, Gladys; a daughter, Ruth; a sister, Anne Goldman, and two grandchildren.

Allard M. Valentine, former president of the Auburndale Cooperative Bank, died on January 23, 1976 after an extended illness. He was a native of Boston. At M.I.T. he was a member of the Chi Phi fraternity. He was a member of the Massachusetts Bankers' Association, the Massachusetts Society of Residential Appraisers, the U.S. Power Squadron, the New England Cruisers' Association, and the Navigation Club of Boston. He is survived by his wife, Anne (Johnson); a son, Allard M., Jr., of Palm Beach, Fla.; a daughter, Mrs. Carla Rose of Brookline; a brother, Cederic, two grandchildren, and a great-grandchild. — **James A. Pennypacker,** Assistant Secretary, Long Hill Rd., Essex, Conn. 06426

24

This note-writing business is as unpredictable as the stock market. The last issue was abundant with news, so several envelope messages were held for this issue; fortunately, they are cheerful news. First, though:

Mitchell V. Allen passed away November 21, 1975 in St. Louis, Mo., according to a note from his widow. We have scant information on his career, since he enrolled in Course III, metallurgy and materials science, but did not obtain a degree. About 1947, he had an office in the Shell Bldg, St. Louis.

A note from Lockwood Oliver, '23, conveys word from the widow of **Vernon C. Ambler** that he died of a heart attack March 15, 1975 in Rockport, Texas, having had assistance from a pacemaker for several years. He was seriously gassed in World War I, and was sent to M.I.T. for two years by the Veterans Administration, and then for health reasons to the University of Arizona, graduating in 1924. In the favorable climate of Paris, Texas, he owned a small factory manufacturing cellophane bags. Upon retirement, he built a home in Rockport.

The Alumni Records office has been advised that **Otto E. Kirchner** died February 5, 1976, location unknown. However, two sons survive him, both M.I.T. graduates in Aeronautical Engineering who live in the state of Washington. Otto earned his S.M. in Aeronautical Engineering after a B.S. in Electrical Engineering at the University of Alabama. His whole career was in aeronautics, occasionally on special assignments for the U.S. government, Ford Motor, Fairchild, Stinson, and American Airways. He was a member of several technical and civic organizations and published manuals and articles in the technical press.

Here follow Alumni Fund envelope messages: **Chris Conway**: "Completed a nine-month consulting project for A.T.&T. in May, 1975. Won 'Garden of the Month' award for September, 1975, from Pineville Garden Club (second time in two years). Am Secretary-Treasurer of Alexandria, La., Kiwanis Club. Spent summer in Kennebunkport, Me. Play golf regularly. Still active in community affairs." . . . **L. B. Feagin** (Dick): "I have been retired due to bad health, but served out my expected time. Was Chief of Planning with U.S. Corps of Engineers, Vicksburg, New Orleans, and St. Louis Districts; District Engineer in St. Louis." . . . **Fletch Fletcher**: "Last fall Ruth and I had delightful visits with son Charles and his wife and four children in Swansea, Wales, and with our daughter Susan and her husband and four children in Bonn, Germany. No external signs of hard times in Britain nor in Germany. We did miss a bombing by a scant half block in London." . . . **Bob Hart**: "Establishment of private laboratory facilities for study and experimental development of dynamic filters, particularly as to clarification of extended action, effect on selective sensitivity, reduction of noise effects and the augmentation or reduction of harmonics."

R. Bruce Lindsay — "National Sigma Xi lecturer, fall of 1975 (topic: Man and Energy). Editor of the following books: *Energy — Historical Development of the Concept* (1975), *Acoustics — Historical and Philosophical Development* (1975), "Physical Acoustics (1974); all published by Dowden, Hutchinson and Ross, Inc., Stroudsburg, Penn." . . . **Bob Morton**: "Hurricane Eloise missed us and hit 100 miles to the East (of Pensacola, Fla.). Golf still the main interest since fishing has been poor the past year. Weather is great — no ice and snow." . . . **Nickey Warren**: "Back in Oregon again. Tried southern California near San Diego for ten months. Too arid for me, but weather usually fine. Have five children and 11 grandchildren. Health great. Regards."

On March 20, **Ed Moll** and Rene, **Gene Quirin** and Ettie, **Frank Shaw** and Barbara, **Herb Stewart** and Winnie, and **Russ Ambach** had luncheon in Brookline, Mass., to discuss a Mini-Reunion on June 4 and 5 (Technology Day) at Old Sturbridge Village, Mass. This beautiful Village is a re-created New England town representing the 50 years following 1776; costumed people reenact that period with hand tools and skills. One may walk to the exhibits or ride in a carry-all. Ed Moll has voluntarily spent years there conducting historical research, planning the layout, and making changes as new facts are found. Nearby accommodations are excellent. Descriptive brochures are available from Ed, P.O. Box 261, Sunapee, N.H. 03782. Make your reservations with him immediately for Friday and Saturday nights (4th and 5th), as he must make a commitment with the management.

We called the sunshine gang in Sarasota, Fla., during their Fourth Florida Fiesta luncheon. Those present were **Joe Tryon, Al Roig, Frank Manley, Paul Cardinal, Clint Conway, Gordon Harvey, Pret Littlefield, John Fitch, Fletch Fletcher, Cy Duevel** and **Dick Shea.** They were discussing a Mini at Ft. Lauderdale in November or December.

Their session began Friday, March 19, with dinner in the British Room of the Sarasota Hyatt House. Saturday events took off with cocktails at Mary and Cy Duevel's apartment on Longboat Key. Some difficulty was experienced with the apartment security system while entering, chiefly because the guards thought the red jackets represented a Cuban invasion. Later, at the Sarasota Yacht Club, they were recognized, and greeted by an astonished sister-in-law of **Nish Cornish.** All agreed that the affair was an excellent Florida Fiesta — **Russell W. Ambach,** Secretary, 216 St. Paul St., Brookline, Mass. 02146; **Herbert R. Stewart,** co-Secretary, 8 Pilgrim Rd., Waban, Mass. 02168

25

Our winter on the Cape has been one to remember for many years. There were four substantial snowstorms, one with wind velocities up to 100 miles per hour, sub-zero temperatures, and — to top it all off — an earthquake on March 14. The tremor registered 2.8 on the Richter scale, not really violent, but most unusual for the Cape.

Tom Lowe says his life's story parallels "The Short and Simple Annals of the Poor." Following graduation in 1925, he joined the staff of the University of Florida, then Auburn University (1939-1952), and Louisiana State University (1952-1964). Since his "retirement" from L.S.U., he has worked in Atlanta with his son, Tom, Jr., under the firm name of Lowe Engineers, Inc. He states, "My principal duty is to take credit for all the mistakes. This helps to keep me young and inexperienced." Tom is a registered professional engineer in some 30 states and the District of Columbia. . . . Madeline and **Will Gardiner** are to be congratulated on their 50th wedding anniversary. How many more of you have passed this milestone? . . . The word from **Fred Greer,** who winters in Naples, Fla., is that about the middle of May, he and Eleanor will head north to their new home in New London, N.H. The Greers were among many M.I.T. couples at a cocktail party given in honor of President Wiesner and Dean Sizer in January.

Roger Ward promised he would attend the 50th, but missed it because he was away on one of his many trips. He is again on the go, this time to Yugoslavia. He is planning to make the 55th. . . . **Joe Russell** reports that he and Ruth are enjoying home life and playing golf frequently. Joe seldom plays tennis now, but can still surprise the younger folks on occasion. He still dabbles from time to time in transactions involving plastics and chemicals.

Do any of you happen to watch "Starsky and Hutch," an A.B.C. cops and robbers saga? One of program's co-stars is Paul Michael Glaser, who just happens to be the son of our classmate, **Sam Glaser.**

It is with sorrow that I have to report the deaths of two classmates. From Mrs. **Sheldon Hare** and **Sam Spiker** comes word of Sheldon's death on October 22, 1975. Shel-

don was retired, having been assistant bridge engineer for the New Hampshire Department of Public Works and Highways. He died at the Concord Hospital after a long illness. He was born in Auburn, Me., and attended Dartmouth College before coming to M.I.T., where he was graduated in Course XV. Sam Spiker writes that he called on Sheldon about two years ago and had a most cheerful visit with him.

Joseph R. Hobbs, M.D., died at the Cooley Dickinson Hospital in Northampton, Mass., on January 19, 1976, following acute congestive heart failure. Joe was a native of Belmont, Mass., attended schools in Weston, and was graduated from Course VII with us in 1925. He went on to obtain a Doctor of Science degree from Johns Hopkins, and in 1932 an M.D. at Harvard University School of Medicine. After interning at Newton-Wellesley Hospital, he began practice in Williamsburg, Mass., in 1933.

Dr. Hobbs was a member of the Hampshire County and the Massachusetts Medical Societies, and he served on the staffs of the Cooley Dickinson Hospital, the Holyoke Soldiers Home, and the Hampshire County Hospital. He was a director of the Northampton Institution for Savings, and served on the Williamsburg Board of Health. For many years he was the school physician. He was with the armed services during World War II, discharged with the rank of lieutenant colonel. In 1973, Williamsburg dedicated its annual town report to him. The book was inscribed, for "many years of faithful service to the townspeople." Besides his wife, Joe leaves a son, a daughter, and four grandchildren.

The notes reaching me by way of the Alumni Fund Office are much appreciated. Keep them coming. — **F. Leroy (Doc) Foster,** Secretary, 35 Woodland Way, P.O. Box 331, North Chatham, Mass. 02650

26

This pre-reunion issue is always perplexing because I will be seeing you about the time this "review" arrives. Rather than excerpt the clippings we will bring them to the reunion in a folder so that each of you can look them over, as well as **Tony Gabrenas'** history of Class of '26 Reunions. It is too long to incorporate into the Class Notes and for me to edit it and boil it down would spoil it. **Pete Doelger** has also become a narrator with a story of his experiences at M.I.T.; so his copy will be included in the binder with Tony's. If any others in the class feel poetic send your composition to the Class Secretary or bring it to the reunion for incorporation in the '26 book.

After a week of mild weather here at Pigeon Cove — 40 m.p.h. winds, ten inches of snow, 18 degrees temperature — it is almost too much to sit here in the living room with the morning sun bathing us through the thermopane. The snow has disappeared, the air is soft and the lobster boats are rushing around in the bay seeking the preferred location for each of their traps. A few hardy souls left traps in the sea all winter but their small catch with the rigors involved made the $2.85 fisherman's price ($3.75 in local markets) less attractive than they had expected.

The predominant news items this month are obituaries. Again rather than giving the details we will paste them in a folder and bring the folder to reunion. For now we will give you the list — which may repeat some from recent issues in case you missed them. They are: **O. Howard Biggs, Arthur C. Sutton, Francis P. Romanoff, Harry J. Hemphill, George W. Wardner, Willard E. Edwards, Martin E. Staley, John W. Spence, Meredith W. Brewster, Alton S. Heyser** and Rev. **Malcolm A. MacDuffie.** The list may be a little longer because the reunion mailings brought replies from widows or relatives of classmates we had not known about. However, most of these deaths were in recent months. There will be a memorial service on Alumni Day in the M.I.T. Chapel which many of you will want to attend.

The Reunion has also brought communications from some who will not be able to attend because of illness. **Gordon Spear** has written that '46 was the only previous reunion he missed but his health makes it impossible to travel. He had been planning to go to Texas for therapy but his wife Dorothy writes that he cannot make that either. Gordon — we will be thinking of you and your loyal attendance at our past reunions. . . . A letter from **Fred Balfe's** wife Rosa tells of an automobile accident that damaged Fred's spine to the extent that he is confined to a convalescent home.

The list of those fortunate enough to be able to attend is growing every day, and there will be a great many that none of us have seen for 50 years. What more can one ask for a 50th Reunion. All of us on Don Cunningham's committee are looking forward to greeting you, and as your Class Secretary for the past 27 years it really will be old home week. Cherrio until we see each other shortly. — **George Warren Smith,** Secretary, P.O. Box 506, Pigeon Cove, Mass. 01966

27

George Cunningham has an unusual annual activity. Each Christmas, he is a volunteer Santa Claus for the children of Laguna Beach, Calif. This past Christmas, he writes, "I balanced 700 Laguna Beach children on my knee. Average 50 lbs. times 700 equals seven and a half tons of kids." George enjoys his contribution toward a happier Christmas for the community — and incidentally, reports that the beard was his own.

"Mo" Smith made a trip to the mainland, from the sunshine of St. Croix last year with his wife to visit their daughter and four grandchildren in August, Ga., and to attend his 50th reunion at Williams College. . . . **Al Schuster** says he is planning to see all of us at our 50th next year. . . . **Carl Anderson** is a trustee of the local Community Hospital and its Foundation, and has been busy fund raising for the past eight years.

Fred Willcutt, who is a reformed hammer thrower, is still an athlete in retirement; he claims to do more distance swimming than any other member of the Congressional Country Club. He is also active in "long-distance small boating" — as much as 180 miles in a single day. . . . **Ed Cahill** avoids boredom by battling the U.S. Army Engineers in an effort to prevent them from flooding out some stripper oil wells just upstream from the new Uniontown, Ky., lock and dam project on the Ohio river. . . . **Dave Knox** writes: "My retirement is anything but dull even though my association with industry and politics is now only as a spectator. We spend the winter months in Lake Worth, Fla., where I frequently see **Dave Truax.** In addition to looking after a handicapped wife, I manage to do some oil paintings and play golf three days a week while in Florida." . . . **Brad Gerrish** is still at Lake Winnepesaukee, doing some fishing and some traveling in the bad months. . . . **Tom Scott** has also been doing some traveling in retirement — to Alabama, Florida, and New Mexico on this side of the water and to Spain, Portugal, and Morocco this year.

Estelle and **Dick Cheney** were in England and the Alpine countries last fall — Switzerland, France, Italy, Austria, Bavaria, and Liechtenstein. They are now back home in Santa Barbara, where Dick keeps "just busy enough" with consulting work. . . . **Ed Damon's** travels included a Mediterranean cruise — Casablanca, Tunis, Carthage, Augusta, Iskenderun (Turkey), Antioch, Cyprus, Istanbul — on a super-freighter. . . . **Francis B.** (Thornie) **Thorne** is active in volunteer work in Rochester, N.Y. After retiring from Eastman Kodak in 1964, he and his wife moved to Santa Clara, Calif., where they organized a Multiple Sclerosis Foundation chapter and were active in the Saratoga Camera Club and Church of the Valley. After two years they moved to Fort Worth; and a year later they decided that Rochester was "home."

Your secretary is still busy in the Finance Department at New Rochelle — until the end of August, when State Law says I shall become superannuated. We went right down to the wire on the budget for 1976 — adopted January 2, 1976; sold a note issue successfully in January; and are presently preparing a prospectus for a bond issue which our banking friends say we should have no trouble marketing — in spite of the fiscal problems of some of our neighboring communities — and which I hope will leave the new Director of Finance without any pressing money problems. — **Joseph H. Melhado,** Secretary, 24 Rodney Rd., Scarsdale, N.Y. 10583

28

The 1976 Fiesta in Mexico was a most enjoyable occasion — the weather was perfect, hospitality was warm and gracious, the program full and exciting. Those who attended were well-rewarded. Our effort to include a '28 mini-reunion in conjunction with the Fiesta resulted finally in only a small response. Those who did go were: Alice and **Vic Decorte,** Frannie and **Jim Donovan,** Florence and **Walter Smith.** Memorable high points included: a visit to the wonderful Museum of Anthropology, luncheon at the University Club, a trip to the archeological dig at Teotenango del Valle where we climbed to the top of an ancient pryamid (now restored), and a gala boat ride at the Floating Gardens of Xochimilco (complete with marimba players, string and brass musicians and colorful vendors all floating along with the special M.I.T. flower boats). The Noche Mexicana was a privilege to experience. This was an evening party held at the exceptionally beautiful home and walled garden of Luisa and Nish Cornish, '24. Amid soft lights, strolling musicians, fragrant spring air and the beauty of exotic plants and flowers, a wide selection of Mexican dishes and drinks were served. The high

point was the traditional breaking of the piñata (in the form of a huge paper beaver) with distribution of gifts.

The Donovans and the Smiths went on the post Fiesta tour, a three-day bus trip to Morelia, Lake Patzcuaro and neighboring points of interest. This provided a wonderful opportunity to see some of Mexico's beautiful mountainous country and the agricultural areas. There were also opportunities to acquire native handcraft products at attractive prices. In a moment of weakness your secretary acquired an oversize guitar and the associated problem of getting it home (2,500 miles!). Furthermore, there had to be a stopover in Florida for attendance at an A.S.T.M. meeting.

Rose and **Maury Beren** graciously hosted a mini-reunion of '28ers and other alumni at their beautiful condominium apartment in Palm Beach on March 20. The guests included Sydney and **Sid Brown,** Barbara and **J. Gordon Collins,** Lillian and **Tom Larson,** Gladys and **Dave Olken,** Maggie and Abe White, '26, Mildred and George Falk, '32, and Florence and **Walter Smith.** This was a delightful occasion and we hope that others can arrange for similar gatherings of classmates, especially now as we approach our 50th. . . . A note from **Chris Case** says that he ran into a bit of misfortune. While making repairs to his home heating system Chris struck his head. The resulting wound required eight stitches to close. Adding insult to his injury, he had to replace the old system finally in order to cure the original problem. . . . **Mac McDermott** wrote to say that he and Marjorie also had hoped to be in Mexico for the Fiesta. However, a previously planned automobile trip through the U.S. Southwest and up the West Coast (accompanied by their granddaughter) proved to be in conflict. . . . Mary (Mrs. **John B.) Russel** sent in a most gracious letter expressing her warm regard for M.I.T. When John retired they bought a 150-year-old farmhouse near their daughter and family. John loved to work with wood and tools and made the place into a beautiful home. Mary is grateful for the 45 years they had together and glad that John enjoyed a full life to the morning he died. . . . A letter from Ethel (Mrs. **Carl J.) Bernhardt** says that she is hoping to make a trip to England this summer. This will be her first visit abroad. Her last trip away from home was to the 45th Reunion at Bald Peak which she remembers with much pleasure.

It is with deep regret that we must report the deaths of five classmates. **Albert Fitch Briggs** died on December 8, 1975. From his wife Dorothy we learn that Fitch had had some trouble with his heart over the years. However, his final illness was brief. Fitch was retired head of Electrical Service, Beaumont Division of Sun Oil Co., retired Lt. Colonel in the U.S. Army Reserve, and formerly president of I.E.E.E. He leaves two sons, a daughter and three grandchildren.

Henry D. Harrington died in November, 1975. The information was contained in a note from his wife Marjorie. Henry graduated in Course IVA. His professional career was with E. I. duPont de Nemours & Co.

George M. Hoffman died suddenly on August 5, 1975. George's wife Barbara sent in a detailed newspaper clipping. After a busy professional career with various prominent firms, George retired in 1971 from the White Superior Division of White Motor Corp. Since then he served as consulting electrical engineer to several companies in the Springfield, Ohio, area. He was a retired commander in the U.S. Naval Reserve. Besides Barbara, he leaves two sons.

Herbert E. Streeter, Course VI, died January 7, 1976, in Springfield, Vt., after a short illness. Herbert had his own plumbing and heating business. His wife Eleanor, two sons, two daughters and ten grandchildren survive him.

We are indebted to Richard T. Lyons, '17, for information on **William H. Woods** who died suddenly of a heart attack on February 8, 1976. Bill was very popular in his home city of Houston, Tex., and highly respected by all. He was retired from Texas Gas Exploration Co. in 1970 as vice president of gas processing. In 1972 he was ordained a permanent deacon in the Catholic Church. Besides his wife Anna he leaves four sons, a daughter, 29 grandchildren and two great-grandchildren.

A note of sympathy has been sent to each of the widows on behalf of the Class. — **Walter J. Smith,** Secretary, 37 Dix St., Winchester, Mass. 01890

29

Richard Piez, like most of us, has retired (almost) and keeps himself busy with sales work for small local firms, house chores, gardening and some travel to change the scenery. . . . **Edward C. Roche** writes, "We are planning to spend our Christmas holidays with our daughter's family in Washington, D.C. I hope you and the rest of our class are well. Best wishes and good health till we meet again." . . . **Neil C. Ross** reports the loss of his wife Alice, last November, after 48 years of happily married life. . . . **John D. McCaskey** was remarried last December to the widow of a friend. He used to take her to the Deke dances at M.I.T. during undergraduate years. John is also a candidate for a Ph.D. in history at the University of Montana. "As **Bell Aldrich** came out of Montana to take M.I.T. by storm," he wrote, "so shall I take Montana by its left flank. Happy 1976 to those who are still here and a toast to those who have departed." . . . **Howard D. Pankratz** writes, ". . . The reason you have not seen us is that we have not been to New England since 1968. The family has been coming to the West Coast for the past several years. We plan to go to Chicago (Evanston) this Christmas for two to three weeks to our daughter's. I might try to visit Boston next June, alone, if nothing unforeseen occurs. Our granddaughter, Alicia Crothers, who spent some time at M.I.T. last summer in architecture did quite well. There is a grandson, Charles Bronson Crothers, (14-years-old) who is building a rocket and wants a full tour of M.I.T., with me as his guide. This gives me an inducement to make the trip. Margaret joins me in sending our greetings to all and wishing good health."

Jarvis M. Hazard is still employed as an inspector of electronic component parts. His inspections are visual as well as mechanical to make sure the parts meet basic electrical performance under electrical stress. "The work I do," he continues, "is varied and non-routine. The reward of all this precious inspection work on parts is a final product of high reliability." . . . **Frederick L. Bray** writes that he was forced into retirement recently and is considering a visit to South Florida to find a suitable location for semi-retired living. "Like so many other wives," he continues, "mine has always dreamt of a home by the sea — a friendly, warm and not so crowded one. The area we choose will have to offer some economic life and opportunities in school, hospital or resort construction, as I would like to work part-time to supplement my social security income." . . . **Laurence S. Newman** writes, "We are now Florida residents (Delray Beach) but we still spend our summers in Maine. We have a mini-motor home, so we take several weeks going back and forth visiting the places and people we like to see, carrying our 'room and board' with us. We still enjoy square dancing. Sometimes, we travel as much as 300 miles or more to get to a good dance. We just returned from an interesting trip to St. Thomas. Jarvis, one of our sons, and his family, chartered a boat and took us sailing, exploring and snorkeling for three days. It was my first attempt at snorkeling, and I found it facinating to see a colorful new world with its underwater scenery. Jarvis builds fiberglass boats in Southwest Harbor, Maine, so there is always something for me to do to keep busy during the summers. Lobster boats and friendship sloops are his specialty."

A note from **Sam Shaffer** reads, "I am still dividing my loyalties among self, real estate and financial consulting. My most interesting client presently is a chain of 500 retail stores in South Africa where my wife Sybil and I go for a month each year. Last summer, we took our youngest daughter (a school teacher) with us and had a most enjoyable vacation. Best regards to all." . . . **Arthur K. Scott** writes, "Sorry I cannot report any glamorous activities, other than the usual household chores, pool-side loafing and listening to gossip in season. We have stayed 'put' since retirement. We are toying with the idea of moving back — maybe in your general area (Hampton, N.H.). Our major accomplishment may be considered the fact that our older son went through M.I.T. with the class of 1961."

Our tentative plans to have a mid-winter mini-reunion in Florida for the class of 1929 did not materialize because of lack of response. In response to it, I received a note from **Bill Saunders,** which reads in part, "We have been in Naples, Fla., for the past eight years. There are about 25 M.I.T. alumni in the city, but I know of only one '29er, besides myself, who is **George White.**" . . . **Richard K. Opper** wished to attend but had other commitments, besides the difficulties of leaving a houseful of priceless antiques.

Charles W. Sampson writes, "In February, 1975, I completely retired from my part-time work. We are now taking life easy. We garden in the summer and travel in the spring and fall. Our daughter and son live within 180 miles of us, so we see them quite often. I just celebrated my 70th birthday and I feel fine. Best wishes to all."

Your secretary and his wife Helen visited the **Hugh Hamiltons** several times this winter as usual. Hugh is holding up well, in spite of his handicap of being confined to a wheel chair. Helen sees to it that he is well taken care of physically, psychologically, and socially. The Hamiltons have a beautiful home in Boca Raton, on the Intercoastal Waterway, which is very colorful, with boats of all sizes speeding by their house. They

spend their summers in New Hampshire.

I regret to announce that three members of our class have passed on. The widow of **Carl M. F. Peterson** has written me a note saying, "In May, 1965, as you remember, Carl had a serious heart attack. He recovered from it and went back to work. He retired in 1971 and we left Arlington (Mass.) and settled in Arizona, which did him lots of good. He liked the climate and fishing and hunting. Last December he had some chest pains, the first ones since his heart attack. He had a fatal heart attack on January 9." Carl was associated with M.I.T. all his life. Aside from his bachelor's degree, he received his M.S. in 1932. He was a teaching assistant in mechanical engineering at M.I.T. from 1929-1931, an instructor from 1931-1939, and assistant professor from 1939-1943. He assumed the duties of superintendant of buildings until 1954 at which time he was made Director of Physical Plant until his retirement.

Dean Emeritus **Thomas K. Sherwood** passed away on January 25, 1976. A full account of his distinguished career is in the March/April issue on page 95. — **Karnig S. Dinjian,** Secretary, 10 Ancient Highway at Plaice Cove, Hampton, N.J. 03842, (603)-964-5363

30

Joe Westell retired as head of the U.S. Bureau of Public Roads in Rhode Island in 1965. Thereafter he went to London as a consultant to the Greater London Council with their plans for a series of ring roads around the metropolitan area. However, the economy could not stand the expense and the people are even more concerned about environmental impact than we are here. Joe says it would take an act of Parliament to build a highway through the "common" lands which have been set aside for the enjoyment of the people. Joe then spent a couple of years as a consultant to the Rhode Island Department of Public Works. More recently he has worked for Waterman Engineering Co. as Chief of Planning. He is now fully retired.

Bill Wye retired from the U.S. Patent Office in July, 1975. He is the last of our four Patent Examiners to retire. He lists commodities speculation among his hobbies and comments that the "action is very fast and very risky." . . . **George (Jeff) Wyman** retired about two years ago but doesn't say from what. As of about ten years ago, he was Plant Manager of the Ozark Smelting and Mining Division of Sherwin Williams Co. He is currently with the International Executive Service Corps in Venezuela and spends time in Caracas. He and Midge recently spent a pleasant afternoon with **Joe Devorss** and his wife, who live in Falls Church, Va. Since his retirement Joe has become an electronics expert and an avid ham operator. He is generally on the air around 8:00 a.m. and his call letters are WB4UOY. Jeff also sees **George Wadsworth,** whose daughter and son-in-law have a cottage next to the Wyman cottage on Martha's Vineyard.

Morris Young lives and works in Manhattan and still practices ophthalmology. He is director of Ophthalmology Service at the Beekman Downtown Hospital, and consults at the French and Polyclinic Medical School and Health Center and the Beth Israel Medical Center. He is well known among magicians and is the author of books on magic and memory. He is first honorary consultant to the Library of Congress in the literature of magic.

Dick Whitehead retired in 1969 after 23 years as Santa Barbara County Planning Director. He has since worked as a self-employed planning consultant. He is a past president of the Santa Barbara Trust for Historic Preservation, and has served on city council committees on housing, redevelopment, and schools. He studies local history and he is writing a book on the Santa Barbara Royal Presidio. Dick's research will be used as a basis for the reconstruction of the Presidio. . . . **Harry Fekas** has retired from his job with the Civil Engineering Directorate of the Tactical Air Command at Langley A.F.B. in Virginia. He plans to do some engineering consulting work. . . . **Mark Purcell** is still practicing architecture in Madison, Wis., on a reduced scale. Now that he has some leisure time, he is indulging in creative writing.

David (Tul) Houston and his wife Anne spent a month in the Orient last fall. His son Dave, Jr. is now in his industrial real estate company and "doing famously." . . . After three years of part-time teaching, **Palmer Boggs** will retire in June. He expects to continue doing some consulting work in structural engineering. . . . **Howie Gardner** is still active as Professor of Chemical Engineering and Professor of Pulp and Paper Technology at University of Washington and does not plan to retire until 1979.

We have a note concerning the death on December 16, 1975, of **Samuel Evans,** listed with our class because he was a Ph.D. candidate in 1930. He decided in the early 1930s to pursue a musical career and studied at the New England Conservatory of Music. He continued with his musical activities, primarily as a vocalist, until about ten years ago, when he retired because of health problems. At one time he sang with the Dallas Opera Company — **Gordon K. Lister,** Secretary, 530 Fifth Ave., New York, N.Y. 10036

31

A thoughtful note from Don Severence enclosed a Wellesley Red Cross brochure which saluted **Larry Barnard** for contributing over 19 gallons of blood through the Wellesley Red Cross Blood Program. More power to you, Larry. . . . Talked with **George Humphreys** on the phone recently. He retired from the U.S. Navy in 1963 after 21 years, then had over five years as Assistant to the President of Benrus Watch Co., followed by four years in the construction business. For the last three years, George has been in the real estate business handling commercial and industrial properties only. George says it is a very slow business but has great potential.

From **Jack Lane**: "My career with Mobil wound up (or down) on May 31, 1974. On June 2, Bert and I left for Europe to complete negotiations for my seven-month consulting job with a grease manufacturer in Lyon, France, and to arrange for a longer-term agreement with a major oil company in France. We vacationed in Spain and the Loire valley — then back to the U.S. In April 1975, we went to Paris where I worked for ten days with my new client; then on to Switzerland for sightseeing." Jack plans to stay in Tuckahoe, N.Y. Clippings tell of Jack's consulting work for TOTAL, Compagnie Française de Raffinage in Paris, and his election to N.L.G.I. as the representative of Condat S.A.

Emile Grenier's Christmas letter tells of Ella's work on the real causes of tooth decay and of Emile's continuing efforts on the promotion of car safety. He's busy feeding racoons and about 100 mallards breakfast and late afternoon lunch on whole corn, and working on a project to secure a five foot sidewalk for school children who now must walk in the roadway.

A short note from **Mayer Hyman** says that he is about to make plans to go to Europe in June and that it would be great to attend the '31 Class Reunion on the way.

See you at the Reunion in June. — **Edwin S. Worden,** Secretary, 35 Minute Man Hill, Westport, Conn. 06880; **Ben W. Steverman,** Asst. Secretary, 260 Morrison Dr., Pittsburgh, Penn. 15216; **John R. Swanton,** Asst. Secretary, 27 George St., Newton, Mass. 02158

32

Ed Burritt raises an interesting query in a recent note — "Are there any plans for a 45th reunion in 1977?" — which prompts the advice to one and all that our Class President, **Don Whiston,** is anxiously awaiting your suggestions and recommendations. The Burritts are enjoying retirement in the Northwest and hope to see more classmates drop in for visits when they are in the area, just as **Carl Wahlstrom** and his wife did last summer. . . . **Francis R. Russell** retired from Exxon Research and Engineering in 1971 but kept active for three years teaching at the Sussex County Vocational Technical School. He is now retired from that job, too, but stays active with the Boy Scouts, and church and lay committee work. . . . **William J. Hallahan** was recently elected Treasurer of Fay, Spofford & Thorndike, Inc. Following a tour of duty in the Army, he joined that firm in 1946 and has been responsible for the management of design and construction coordination on industrial facilities, highways, civil and military airfields, utility systems, and waterfront work. . . . **Al Dietz** is back at the Institute in teaching and research after a sojourn as a Visiting Professor at the University of Hawaii and as a Senior Fellow at the East-West Center, both in Honolulu.

Robert S. Prescott, who retired in August, 1974, is preparing to move to Phoenix, Ariz. Bob and Lou have decided to leave the cold, cruel New England winters for a spot they purchased several years ago. Both their boys are living in Rochester, N.Y. Robert is in business for himself as a land surveyor. Theodore is teaching art at Roberts Wesleyan University. . . . **Sidney B. Jeffreys** is retiring during the early part of 1976 from the Jeffreys Engineering & Equipment Co., which he founded in 1946. He incorporated the company in July 1, 1959, and was president and treasurer until October 1, 1974, when he was made chairman of the board.

Jacob Millman is retiring from his position of Professor of Electronics at Columbia University. His seventh book on electronics has just been published, a one-semester

course for engineers and scientists entitled *Electronic Fundamentals & Applications*. His son Jeffrey obtained his Ph.D. in electronics at M.I.T. in September, 1975, and is now at the Lincoln Laboratories. Son Richard is now Associate Professor of Mathematics at Southern Illinois University. . . . **Russell W. Abbott** has retired to St. Petersburg, Fla., where he has bought a home. He keeps busy consulting in structures and allied civil engineering fields. . . . **Theodore M. Lichtgarn** gardens, plays violin in a string quartet, visits with friends and relatives, and maintains an interest in public affairs. . . . **Samuel E. Paul** is finishing his "pay back time" to California by working a full time 40-hour week at the Metropolitan State Hospital. When his time is completed next June, he will change from half to full time teaching Family Practice as an Associate Clinical Professor at U.C. Irvine. . . . **James M. Shackelford** is working on the revitalization of the downtown area of his hometown Marietta, Ohio. The project is called Restoration '76.

Carl J. H. Wahlstrom and his wife visited **Ed Burritt** and his family at their new retirement home in Sequim, Olympia Peninsula, Wash., where they have a beautiful view of Puget Sound and the Hurricane Ridge mountains. It was their first get together since '32 and among the activities enjoyed was a Rotary Club picnic with smoked salmon, Indian style.

A sad note from **Jim Harper** contains the news that **Joseph L. Richmond** died on January 26, 1976. Joe was former Manager of the du Pont Chambers Works at Deepwater, N.J. He received his S.B. degree with us in 1932 and continued until he obtained his doctorate — all in Course V. He lived in Woodstown, N.J., where he was very active in civic affairs. He is survived by his wife and four children to whom we extend our sincere sympathy. — **John W. Flatley,** Secretary, Apt. 204, 5100 Dorset Ave., Chevy Chase, Md. 20015

33

The headline this time around is for **Bob White**; long-time friend, just retired as Vice President of the Torrington Co., of same place, Conn. **Ellis Littmann** sent me a clip from the home town paper, about the 400-place dinner given for Bob upon his ending of over 42 years of service with his company. Bob is the holder of ten patents, one of which is the Needle Thrust Bearing, a device now used in automatic transmissions in automobiles. One feature of the program was a framed display of ten silver dollars, each representing one of Bob's patents. Our very best wishes to our distinguished long-time friend and most loyal Classmate.

We have several notes from a few classmates who wrote to say that they would or would not, be able to take in the Fiesta: **Ellery Clark, Art Hayden, Bill Huston,** and **Chuck MacMillan.** (We will hold the Fiesta report until June.) Chuck added that he lived in Pompano Beach, 1946 to 1950, fished out of our Hillsboro Inlet, and was on the zoning board as Secretary. We overlapped about two years, as we started our annual Florida trek in 1948.

Now comes reports from Alumni Fund capsules. **George Wrigley** says that he is now retired as Chairman of the Board, the J. E. Sirrine Co., as of October 31, 1975. . . . **Edward W. Kimbark** received the Distinguished Service Award of the U.S. Department of the Interior in June of 1964. . . . **William A. (Bill) Gray,** who allows that he retired from the C.I.A., resettled in Jefferson country, in a hayfield, with the Blue Ridge Mountains on three sides, in a moonshine hollow. He runs the Madoc Hall Nursery for fitness and revenue, and does some electronic consulting, with some research and writing. He has two step-sons, and two daughters-in-law, and four grandsons. It runs in my mind that Bill was a long time friend of **Ed Goodridge.** . . . **Julio Ulloa** writes from Fort Lauderdale saying that he is advisor to the Ministry of Industries, Foreign Trade, and Intelligence of Ecuador, under contract with United Nations.

From the great state of Maine we have one from **Forrest P. Dexter, Jr.,** who says that he has been retired four years, but still teaches one semester each year at the University of Maine at Farmington in environmental geology, geology of Maine, human paleontology, and geology-archeology. He is also active in mountain climbing, hiking, snowshoeing, and white water canoeing. . . . **John T. MacIssaac** retired last year and has moved to Marshallberg, N.C. He bought a 42-foot boat, and spent a year rebuilding it, and now plans to cruise to Maine in the summers, and Florida in the winters. And, not unusual, he does a little consulting. . . . **Paul J. Petitmermet** writes that he has moved to a condominium, where he now has no leaves to rake, lawns to mow, or in a nut shell, freedom, which includes freedom to travel. He has already been to Bermuda, the west coast of Mexico, and our southwest, with Europe next on the agenda.

Our old friend of many years, **Stan Walters** has three children, all in college, which he thinks must be a "record," (except for Murphy). . . . Fellas, this was not planned! **Frederick V. Murphy, Jr.** is the next one down from the top. "Still slugging it out in the plastic business, but taking it a lot easier. Number two son, Thomas, is in the business, too. Number three daughter graduated from U.V.M. this year. Five down and two (sons) to go. Social Security will pay for these." Fred apologizes for not replying to a message in which I asked if he knew **Muriel (Bliss) Wilbur,** one of our more distinguished classmates. Fred says that he has known Muriel all of their lives, and that she is a great girl. . . . From **John G. Hayes** comes a short one, but pithy: "Retired from American Can Co., three years ago, and now in Consulting, Air Resources, to San Francisco Bay area League of Industrial Associations, and others." (What ever happened to **Jim Hayes,** same area?)

This next one posed a bit of a translation problem, but, Leona made it, or nearly so. **Lewis N. Miller** tells us that he is now President of Building Material Wholesaler, and its Chief Executive Officer. They have recently moved into a multimillion dollar facility, just outside of Richmond, Va. . . . There is a lot of comfort in this next one: Emmy **(Emerson) Norris'** wife Christine wrote that he is making a fine recovery from his severe stroke of a year or so ago. He drives his car, spends a lot of time in his workshop, walks to the post office every day, in all weather, and is quickly learning to write again.

Every once in a while I get one which makes me very close to being a candidate for the mortuary; this time it is **Frank Vanucci,** an old Course II, from Newark, Ohio. "After 43 years with Owens Corning Fiberglass Corp., in engineering, research and development, and manufacturing — this last with the International Division of O.C.F. — this is the year of retirement." The Vanuccis have two children; an unmarried daughter, who works as an x-ray technician, and lives in Columbus; and a son who is married, and Vice President of Women's Savings and Loan in Cleveland. To this we add one grandson, Michael Peter. Eve and I hope to do a bit of traveling." Now, to all and sundry, if you keep pounding away, the law of averages says that someone will reply, and after 43 years, I got Frank. And, especially thanks to Frank. I hope his attitude is contagious.

World traveler, **Mal Mayer,** sends us a card from Chile, where the Mayers stopped on their way to Easter Island. He really travels and he can't be selling beer, if anything, it must be beer machinery.

Early in January, Leona and I went over to Venice to see our son, the Senator Warren, who could not be with us at Christmas time, and, with three classmates close by, we did some visiting. In Sarasota we found Marge and **Prentiss Lobdell** at home on Longboat Key. Within a day or so, we located Colonel **C. T. Newton** and his lovely Fran, only five miles away in Nokomis, on a tidal estuary, right off the intracoastal waterway. We were invited to lunch with them, and who should turn up but the Lobdells. It appears that the two of them were born and raised in Melrose, rode to Cambridge together, and have been close friends ever since. On the way home, we stopped in Punta Gorda to call on **Dick Payzant,** who is still active, but taking it a lot easier. Dick and his lovely wife, Emma, have a new home on the Punta Gorda Isles waterway, and Dick has his sailboat tied up right at his front door. Earlier, we had tried to get in touch with **Ken Moslander,** who lives in Fort Myers, but with no luck.

We had a caller, recently, our first from the class this year: **Fred Aldridge** has moved from Seattle to Miami. Fred has been in public health all his working life, and his new job is with the Dade County Health Department, in charge of fresh water resources and supply. He intends to stay in Florida for one more year and then move to the town of his birth, Chester, Mass., where he will become Town Engineer, probably without pay (I quote). Golly, I almost missed a short one from **Olavi Viita** (also a Chester boy), who announces that his children are all out of school. Olavi was retired from Metcalf and Eddy of Boston, but since has been called back and is still there. They built a retirement home at New Seabury on the Cape and will use it if Marie ever stops working.

We have one more classmate who has gone to his reward, **John A. Maxim,** of Wakefield, Mass. John passed away in December, 1975. Mrs. Maxim has our sincere sympathy in her loss.

That's it for this time around. Leona and I send our best wishes. Why not consider, in your recent leisure, attending the coming Technology Day? — **Warren J. Henderson,** Secretary, Fort Rock Farm, Drawer H, Exeter, N.H. 03833

34

Though the notice comes somewhat belatedly from the Institute, we now learn that in last year's elections **Wilfred D. MacDonnell** was selected for a five-year term as one of the nominees to the Corporation of the Alumni Association. After work with Bethlehem Steel, National Steel Co., and Great

Lakes Steel Corp., Mr. MacDonnell joined Kelsey-Hayes in 1962 as Vice President and became President and Chief Executive Officer later that year, a position he still holds.

In January, **Francis J. Dowling** was appointed "agent of record" for Meriden, Conn., where he maintains an insurance business. He has long been active in local democratic politics and in the Knights of Columbus.

Meyer Baskin died in Coral Gables on October 27. After receiving a B.S. in science at Harvard he took his S.M. in chemical engineering at M.I.T. (in 1934) went on to a law degree at New York University, and entered patent law, working with the Army on patentable aspects of the work being done by Enrico Fermi's team on the Manhattan Project. In 1946 he moved to Miami to establish the patent law practice in which he continued until his death. He was active in both Jewish and Masonic organizations and only recently retired as a major in the Army Reserve. Meyer is survived by his widow Florence, two sons, a daughter, and a granddaughter.

George T. Fisk of Westerly, R.I., died suddenly in Florida on January 9. He was a former president of A.T. Cross Export Co. and earlier had been a General Traffic Manager for Booth American Shipping Corp. In his immediate family, he is survived by his wife Marjorie, a daughter, and three sons.

In December I noted that both **Johnnie Westfall** and his wife Frances had been ill. Now we learn that Frances' fight was with cancer, and I learn from **Larry Stein** that she died in February.

The sympathy of our class goes to all the families who have suffered these losses. Frances' passing touches me more closely personally because of our acquaintance through reunions.

I have an extremely interesting — and almost equally sombre — letter from **Edward Taylor.** A winter trip to Mexico started in Yucatan. They wanted to fly on to Guatemala but couldn't get seats so went by bus, including a hair-raising bus ride in the clouds over the Continental Divide. Quetzaltenango and then to Panajachel on Lake Atitlan, "so beautiful that we decided to stay for at least three weeks." They were there on February 4, when the first and worst quake hit — "28 seconds of wild rocking with glass crashing on the floor and all lights off. Fortunately we were in a strong, one-story bungalow so the roof remained intact and only minor cracks developed in the walls. When it let up we groped our way outdoors as did everyone else and rode out later severe shocks that night in the hotel proprietor's van with his family.

"For two days Panajachel was completely isolated — the two roads blocked by slides and no telephone, telegraph, etc. — only bits of news over a short wave radio. Later we found that surrounding villages were completely destroyed.

"Such a disaster is beyond comprehension. We stayed on through six days and nights of occasional shaking (we slept under the stars — it was worse after dark). I think the count of shocks was over 800 when we finally left, by bus to the Pacific coast — relatively undamaged — and then to Oaxaca; almost all Americans had gone by then, but in those first four days or so we were really glad to see our young people (hippies?) pitch right in to form volunteer teams to take food and medical supplies to the disaster area nearby. They were great." Now the Taylors are home after six weeks in San Miguel.

I still hold several Alumni Fund notes; since I've already mentioned Larry Stein, let me include his: "Have first grandchild — Michael S. Peluse, born September 19, 1975." Larry can now qualify for my wife's line, "How are your grandchildren, and I'll let you have just five minutes." — **Robert M. Franklin,** Secretary, Satucket Rd. (P.O. Box 1147), Brewster, Mass., 02631; **George G. Bull,** Assistant Secretary, 4961 Allan Rd., Washington, D.C., 20016

35

I am pleased to start these notes with another letter from our Swedish correspondent, **Robert W. Forster:** "We are well. It has been a long winter. Not much snow and not really cold, but a steady 15-25 degrees for two and a half months; short days with very little sun. My job since September has a broader base. They gave me responsibility for Scandinavia. It is a semi-official job. I have now traveled so much that I do not look forward to it. This year I have been to Helsinki and Copenhagen twice, Oslo, Brussels, and Zurich. George, number four son, spent Christmas with us from December 3 to 27. It was fun having him here and he seemed to enjoy it. He plans to come back this summer. It doesn't seem possible that we have been here 14 months. The end of the track is coming up fast. It has been and is interesting. We still have many things to see and do but I shall be glad to get back this fall."

Frank R. Hatch sent a note through the Alumni Fund: "I am comfortably retired after 39 years with Shell Oil Co. Occasionally I have done some consulting but my primary endeavor is to improve my golf at the Stanford Golf Club. We looked into moving north to Washington, where my wife grew up, but are still enjoying California. We may take a trip East this spring." Frank, you are going to receive a notice for the Class Golf Tourney to join **Brownie Brownell, Ham Dow** and **Gerry Rich** in the general area.

June Brownell wrote: "As the new President of the Monterey Country Club, Brownie is just as busy as when he worked for General Motors. He did resign from the Monterey Symphony Association Board which lessens the load a little, and manages to squeeze in a round of golf occasionally. My game has gone to pot, so off to the practice area. I have taken five lessons but sorry to say I am more confused than ever. Brownie sends best wishes for 1976."

Elmer J. Roth, now of Burnt Hill, Warner, N.H., was named Director of Financial Affairs at New England College. Since moving to Warner in 1972, he has been engaged in consulting in the field of financial planning. Prior to his semi-retirement, Elmer was Vice President of Finance with several nationally known businesses including: Locktite, Fafnir Bearing, and Stop and Shop. He is a member of the New Hampshire Regional Planning Committee, General Chairman of the Warner Industrial Development Committee, and a Trustee of the United Church of Warner. . . . **Clarence D. Davis,** a professor of obstetrics and gynecology at the Yale University School of Medicine, has been appointed Educational Director of St. Vincent's Hospital in Bridgeport, Conn. Clarence was a Course XII man with us and then went on to Johns Hopkins University for his medical degree. He has had a long and illustrious career and has made significant contributions to his field, having authored or co-authored 83 publications relating to the study of obstetrics and gynecology. He joined the Yale University staff in 1957 after three years at the University of Missouri. He was appointed a full professor in 1964. . . . **George S. Schairer,** Vice President in charge of research at the Boeing Co. has been elected by his peers, the Fellows of the American Institute of Aeronautics and Astronautics, to the status of Honorary Fellow. George received his Masters Degree with us and went on with Bendix, Consolidated Vultee, and finally Boeing to become recognized for his leadership in aerodynamic design. He has guided the aerodynamic design of practically every airplane built by Boeing during the past 30 years.

Rhoda and **Bernie Nelson** had lunch in New York with Elizabeth and **Walton Marshall** who were staying in New York but live in Farnham, Va. Walton is "a farmer and management consultant" according to Bernie. They were also joined by Mary **Lavenas,** widow of **Carlos,** who also lives in the city. Bernie has been a member of the U.S. Power Squadron for 20 years, and now is taking a course in junior navigation. He and Rhoda live in a charming Cape Cod home. Recent guests included **Don Gittens. . . . Henry (Hank) F. King** and Elsie are now living in Chatham on the Cape. Hank retired from Mobil Oil Co. in Pittsburgh on January 1 after 34 years with the company. He is currently working toward a realtor's license. He and Elsie live at 105 Vinyard Ave., Chatham, Mass. 02633. . . . **Randy Antonsen** retired from the Cabot Corp. on January 31 but couldn't stand still. Beginning March 1 he will be working with the Energy Research and Development Assoc. in Washington, D.C. He will be in the Fossil Fuels Div. converting coal to gas.

Plan to come and be sure to let me know re the dutch treat dinner at the Faculty Club on June 4. Call me now: (617) 244-9032 — **Allan Q. Mowatt,** Secretary, 61 Beaumont Ave., Newtonville, Mass. 02160

37

Thomas A. O'Brien has been elected a corporator of the Home Savings Bank of Boston. Tom is a contracting officer for the U.S. Dept. of Defense. He and his wife Helen live in Wellesley. . . . **Sidney B. Karofsky** received the Justin P. Allman award at the annual convention in January, 1976, of the Wallcovering Wholesalers Assoc. This is the Association's highest award. Sidney is Chairman of the Board of Northeastern Wall Paper Corp. which he founded in 1957. He is past President of the M.I.T. Alumni Stein Club, the Hillel Foundation, and the Hebrew Rehabilitation Center for the Aged. He is a current Trustee of Bnai Brith, Hillel House, and a past Trustee of Hecht House. He is also a director of the Commonwealth Bank and Trust Co. Sidney's wife, Sylvia, manages Walls Unlimited, a designers showroom. Sylvia, an expert braillist, recently contributed to their husband-wife exhibit of water colors, ceramic painting and needlepoint. His son Paul, is president of Northeastern Wall Paper Corp. Son Peter, is a pediatrician practicing in Wisconsin. His wife, Judy, is the Mayor of Middleton, Wisc. Sidney and

Sylvia have five grandchildren.

James A. Newman, Vice Chairman of Booz, Allen and Hamilton Inc., has been elected a director of Industrial National Corp. He joined Booz, Allen and Hamilton in 1946, became an officer of the corporation in 1951, and later assumed direction of all international activities. During the past ten years he has been involved with the interaction between government and industry, having performed two large studies for the National Association of Securities Dealers Inc., two for the Price and Incomes Board in England, as well as numerous others for state and city assignments. . . . **Roger H. Wingate** has been named co-chairman of the Advance Gifts Div. of Melrose-Wakefield Hospital's "Dedication to Excellence" campaign to raise $1.2 million toward the hospital's building program. Roger is a senior vice president of the Liberty Mutual Insurance Co. in Boston and has been Town Moderator in Wakefield, Mass., for almost 20 years. He is a director of the Wakefield Historical Society, the Melrose-Wakefield Trust Co., the National Safety Council, the Board of Certified Professionals of the Americas, and the Charles T. Main, Inc. He is also Chairman of the Board of the American Mutual Reinsurance Co., of Chicago, Ill. He and his wife have four children. — **Robert H. Thorson,** Secretary, 506 Riverside Ave., Medford, Mass. 02155; **Lester M. Klashman,** Assistant Secretary, 198 Maple St., Malden, Mass. 02148

39

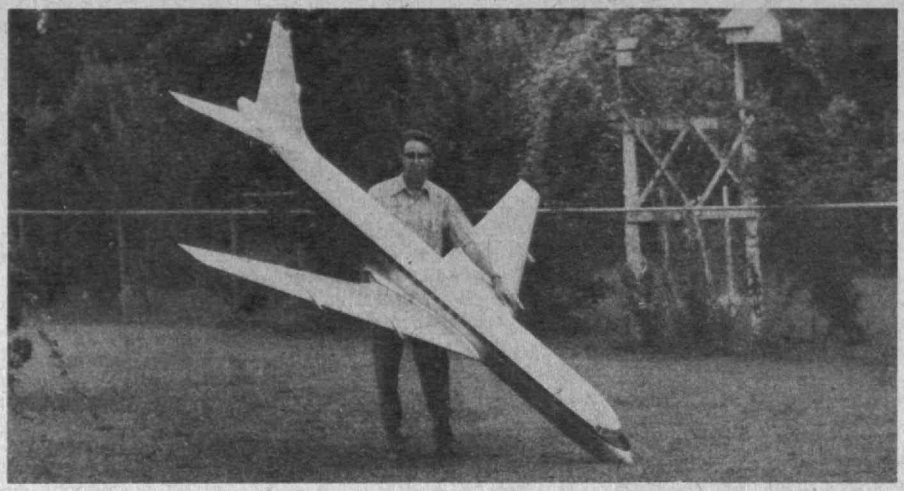
Harold F. Muckley retired as president of Houston Contracting Co. and now consults in Houston. Harold was recently elected to the M.I.T. Corporation.

W. Hewitt Phillips wrote about some of the Course XVI alumni who live on the East Coast: "When I came to N.A.S.A. at Langley Field during 1940 some '39ers were already there: **Dick Sears, Norris Dow, Art Vogeley,** and **Wilbur Gray.** Art Vogeley was head of the Simulation and Human Factors Branch, and left to head a consulting business in Yorktown, Va. Dick Sears went with Raytheon in Massachusetts years ago. Norris Dow went to General Electric at Valley Forge, Penn. Wilbur Gray joined McDonnell-Douglas at St. Louis.

"Other '39ers of Course XVI who have important positions in the aero industry on the East Coast include **Wes Kuhrt,** now President of Sikorsky Helicopters, and **Leo Weiss,** President of Avien Instrument Co., which makes fuel gauges for many of our airplanes. **Harold Pope** and **Walter Mykytow** are active, too. If these classmates see their names in print they will let us know more.

"At N.A.S.A. Langley Research Center I am the last of our original group, and am now Chief of the Flight Dynamics and Control Section. Last year Viola and I were in Europe for nearly four months. We visited aeronautical research laboratories in France and Germany. I lectured for about three months at Cranfield Institute of Technology in England, and also at Universities in Southampton and Glasgow, and at England's equivalent of our N.A.S.A.

"My hobby is model airplanes, and my latest is a 10-foot span soaring-scale radio-controlled glider model of a DC-8.



Hewitt Phillips, '39, with his ten-foot radio-controlled soaring model of a DC-8

"I was interested in your note about Bob Fife, '40, because he was my high school classmate at Belmont High School. Other Belmont classmates in '39 are **Stanley Johnson, Joseph Perry,** and **Alan Schreiber.** What ever happened to **William E. Davies** and **Winthrop B. Reed**?"

Bill Love's career has included engineering for the Nashville, Chattanooga & St. Louis Railway, bridge designing in Saigon, Viet Nam, entrepreneuring his own business in Nashville, and engineering now with Jones and Laughlin Steel Co. Bill collects old popular and jazz phonograph records. Bill wrote: "It would be nice to read about some of my old Tech friends, including **Jack Chatten, Perry Crawford, Manning Morrill, Bobby Davidson, Bernie Vonnegut,** and **Carl Olson.**" These six should write Bill Love at 5808 Northumberland St., Pittsburg, Penn. 15217, and send along a carbon for me for a future edition of these notes.

Ernie Ohsol is Corporate Manager, European Fluid Processing Division of Selas Corp. and lives near Munich, Germany. . . . **Fred Schaller** reports business goes well at East Coast Plastics. Fred and Anne invite classmates with know-how and enthusiasm to join them for cruises on their 35-foot sailing boat. . . . **Ernie Kaswell** has jetted his mundane textile business into orbit by designing and planning certain insulating pads and tiles on space shuttles. I am a bit frustrated by this newsbit from Ernie because, try as I might, I just haven't been able to get my earthbound fertilizers business much higher than a plowed furrow.

Lawrence Cavendish reports his plans to retire and move to Cape Cod this summer. . . . **Chua Hoonchamlong** wrote he is retired from State Railways of Thailand and is about to start farming a plot of land in suburban Bangkok. . . . **Dan T. McDonald** has undertaken Presidency of Consolidated Storage, Inc., which is in the business of storing light hydrocarbons underground. Dan will headquarter in Houston and visit storage facilities in Hutchinson, Kansas. . . . **Art Morrell** reports from Buchanan, Mich., that he is working with Clark Equipment Co. to reduce noise made by large construction and factory machinery, to meet government-imposed limitations and to ensure a quieter environment. Art, what have you got for barking dogs at night in the neighborhood?

Simon Roberts has spent many years in the laundry and dry cleaning business and has now focused his primary attentions on Daloz, a cleanser and on Ram Leather Care. Simon heads a national committee which is developing "cleanability" standards for leather garments. . . . **Ed Tatman** has retired from Alcoa and became a grandfather during October. He didn't write that the two events were at all connected, but he wrote, "Life at a slow pace ain't half bad." . . . **Abner Towers** reports remarriage a year ago. Ab is President of Aday Chemicals which makes iodine chemicals.

We are saddened by news of the death of **David P. Triller** in Indianapolis. — **Hal Seykota,** Secretary, 2561 Via Viesta, La Jolla, Calif. 92037

40

Top Honors: To **George O. G. Löf,** Professor of Civil Engineering at Colorado State University, Director of C.S.U.'s Solar Energy Applications Laboratory, the 1975 Lyndon Baines Johnson Foundation Award. The $25,000 cash award is presented annually to living Americans who have made a substantial contribution to the betterment of mankind in their fields of endeavor. Löf is the immediate past president of the International Solar Energy Society, and vice president of Solaron Corp. in Denver.

Statistics: M.I.T. records show 509 bachelor degrees were awarded to the Class of 1940. The roster for 1975 lists 438 surviving 35 years later, all but 54 resident in the U.S.A., but no one in Alaska, Arkansas, Hawaii, Nebraska, Nevada or Wyoming.

Dream Come True: **Charles V. F. Demailly,** as president, and **Robert L. Millar,** as senior vice president, are the principal stockholders of PCI GROUP, Inc., which has acquired manufacturing and distribution facilities in New Hampshire, Maine, New York, Missouri, Tennessee, and Canada, forming the largest integrated shoe industry supplier in North America. From New Bedford, Mass., Charlie says, "Suddenly, on the way to my 58th birthday, I am involved in the biggest deal of my life."

Electronics: **Norman L. Laschever** is named manager, Electronic Warfare and Radar Programs for R.C.A. Automated Systems Division, where he has been since 1962. Norman lives with his family in Lexington, Mass.

Government Service: **H. Garrett Wright**

is serving as General Councilman on the City of Springfield, Missouri, governing body. "This is a non-paying service that I felt I owed to my community, but I doubt that when the four year term of office is over I'll feel any further obligation." Garrett travels to Kitty Hawk, San Francisco, and other U.S. points each year to visit his children and grandchildren.

Now for 1976: **Charles S. Godfrey,** of Berkeley, Calif., had many meaningful experiences this past year including a Hawaiian vacation, hip joint replacement, brain wave scans, and a visit by a team from the French Atomic Energy Agency to Physics International, where Charlie works. He assures everyone he is ready for 1976.

Easy Does It: Architect **John H. V. Evans,** Toledo, Ohio, chief designer for Samborn, Steketee, Otis and Evans, Inc., has retired to a consulting capacity with the firm. "I have reached the point in life of wanting to slow down somewhat with a more leisurely pursuit of my goals."

In Memory: **Edward Lee** died January 22 in New York City. Services were held in Boston on January 29.

Random Roll Call: Each month I select randomly from the Class of 1940 roster. If your name is listed here, no prize, but we all want to hear from you. What are you doing? Launching a new career? In Politics? Gone Fishing? — **Richard F. McKay,** Natick, Mass.; **Joseph P. Paine,** Baltimore, Md.; **John Parnell,** Littleton, Colo.; **Edward D. Crosby,** Wilton, Conn.; **Robert G. Hall,** Baltimore, Md.; **Philip M. Garratt,** Amsterdam, N.Y.; **Richard M. Dunlap,** Middletown, R.I.; **Harry E. Martin,** Newport Beach, Calif.; **W. Kenneth Bodger,** Fresno, Calif.; and **Benjamin A. Bosher,** Danielson, Conn. — **Frank A. Yett,** Secretary, 1405 Ptarmigan Dr., Walnut Creek, Calif. 94595 (415-933-9807)

41

Again **Larry Turnock, Jr.** makes the news; he was elected President of the American Iron Ore Association. The announcement read that he replaces "Hugo Johnson who has been 'Mr. American Iron Ore' to many thousands of people the world over." Will Larry take on that mantle?

Charles Townes has been elected to the National Inventors Hall of Fame for his invention of the "maser." Other inventors so recognized are Fermi, Diesel, Goodyear, and Cyrus McCormick. . . . I had lunch in Pittsburgh with **Don Scarff,** President of the Pennsylvania State Chamber of Commerce. He is also Regional Vice President for General Electric. . . . I also had dinner with **Ray Harper** and his wife, Peggy, in San Francisco. He is in the business of founding new banks.

Y. S. Touloukian has been elected President of Purdue University's chapter of Sigma Xi. He is Distinguished Atkins Professor of Engineering, and an international authority on thermophysical properties of matter. . . . We had a note from **Robert Purvin** who relates that he is now President of Barber Oil Corp., with offices at 200 Park Ave., New York City.

We heard of **Carlton Stewart's** death from his wife, Marjorie. He had been in a wheelchair since the onset of polio in September, 1956. He was Assistant Plant Engineer for Penn-Central until three days before his death, and his courage was inspiration to us all. To Marjorie, his daughter Nancy, and surviving family we offer our sincere condolences.

Robert D. Mellen died January 31, 1976. Our sympathy to Robert's family.

Leona Zarsky, our Class Reunion "Chairperson," urges all of you to attend our 35th Reunion at the Institute June 3-6. A great program has been arranged. See you there! — **Henry Avery,** Secretary, U.S.S. Chemicals, 2863 — 600 Grant St., Pittsburgh, Penn. 15230

42

John C. Haas, Chairman of the Board of Rohm and Haas Co. has been elected a life member of the Corporation. He has been a member of the Corporation since 1970. . . . **Al Clear,** Executive Vice President of the Stanley Works was elected to the Board of Directors of the New Britain (Conn.) Bank and Trust Co. . . . **W. Van Alan Clark, Jr.** was elected a trustee of the Woods Hole Oceanographic Institution. . . . **Henry Hill** was elected President of the American Chemical Society. . . . **Don Berkey** has been appointed General Manager of the General Electric Co. Energy Systems and Technology Div. Don joined G.E. at Schenectady in 1943 and has worked for the company at Lynn, Evendale, Ohio, and Bridgeport.

When in Manchester, Conn., do stop in for lunch or dinner at **Mark Kravitz's** "Steak Club" — the menu looks great. . . . **Ed Telling** moved from large to small corporate activity and reports that the switch is "exciting." He resigned as President of Brewer-Titchener Corp. and bought Gunite Assoc. . . . **Carl Trexel** is still with Stanford Research Institute doing a variety of studies in the field of energy and related matters. . . . **Norm Pinto,** Vice President of Kawecki Berylco Industries in Reading, Penn., was interested in our account of **Ranulf Gras'** sailing cruise. Norm just completed a 1,200-mile cruise to the Caribbean on his 35-foot ketch. — **L. K. Rosett,** Secretary, 191 Albemarle Rd., White Plains, N.Y. 10605

44

This is the first report on class activities from your new team. Although I am listed as Class Secretary, Melissa is doing the typing and editing. As **Melissa Wood** she was an M.I.T. coed and a Field Day cheerleader for what became the class of X-'44.

As yet there is scant news from our classmates. Some of them have ended up on the roster of the Class of '47 as a result of what used to be called "the late unpleasantness" deferred graduation in 1947. We hope that for old times' sake, they will scan the reports for this class to find out what their former classmates have been doing.

We want to hear from everyone. We don't want to have to rely only upon news releases and clippings. Finding out that "Ole Joe" has just become president of General Motors can be depressing to those of us who feel that we should have received a similar honor; but it does help to know that it's our "ole Joe" to whom we should send our congratulations. However, there are two members of the class who were honored for their professional achievements during the last year or so: **Andy Corry,** who joined Boston Edison after graduation, was named a Fellow of I.E.E.E. (this was before Boston Edison promoted him to Vice President); and **Larry Varnerin,** who went on to get his Ph.D. at Tech in 1949 and thence to Bell Labs, also received the Fellow award from the I.E.E.E. in 1974.

A news release from the Resource Sciences Corp. announced the promotion of **Wilson N. Gilliat** to Senior Vice President of the corporation. He had been Senior Vice President of Williams Brothers Engineering Co., an R.S.C. subsidiary. . . . **Nathan Sonenshein** writes that since his retirement from the U.S.N. in 1974, he has been Assistant to the President of Global Marine Development, Inc., at Newport Beach, Calif. . . . Did you note in the *Tech Review* of February, 1976 that **Alan S. Michaels** was honored in 1975 by the American Institute of Chemical Engineers as their 27th Annual Institute Lecturer?

Bob Veitch wrote that he is still with Grumman but is on loan to the Georgia (he spelled it "Jawja") facilities in Savannah. At last report his wife Pearl and son Bobby were to spend the Christmas holiday season with him in Georgia.

Since 1974 we have been in charge of the extra Armetale® bread trays bearing the great seal of M.I.T. and the Class of 1944; they were given to those members of the class who gathered at the 30th reunion in Bermuda. We would like to deplete our collection for the sum of ten dollars per tray. Meet us during Alumni Day activities at M.I.T. on June 4. Call us if you are in the Boston area. Melissa has been recruited by Electro '76 for the Ladies Committee, headquartered in the Sheraton-Boston Hotel, and will have some trays there with her.

I hope to see some of you at Electro '76 (I.E.E.E., E.R.A.), May 11-14 at the Hynes Memorial Auditorium and the Sheraton-Boston Hotel. — **Newton A. Teixeira,** Secretary, 92 Webster Park, West Newton, Mass. 02165

46

Max D. Daggett, Jr. is a manufacturers' representative for technical sales of instruments and controls to the aerospace, oil and petrochemical industries based in Dallas. Max represents international clients, and so traveled to the Soviet Union twice in 1973, to Vienna and Western Europe in 1974, and to Mexico in 1975.

Jim Craig says he left HCA/Sonesta a few years ago because he wanted to work in public service. He joined a friend, Carl Koch, at the Boston Waterfront Development Corp., to renovate and develop the Lewis Wharf area of Boston. They converted the Granite House into a commercial office, retail, and condominium space; the Pilot House into a restaurant; and rehabilitated the Steel Shed Marina for the present (M.I.T. Oceanographic Unit) and future tenants. Jim became president of the Boston Waterfront Development Co. in 1972. In early 1975, with the end of the Lewis Wharf project in sight, Jim joined the Technical Development Corp. and became president of Transitional Employment Enterprises, Inc., of T.D.C. The organization plans, develops and operates a network of small en-

terprises in Massachusetts to provide employment for youth and adult offenders, alcoholics, drug addicts, and welfare mothers. With the advent of the recession, the organization found very high unemployment rates among the people it wished to serve and a financial crises in the state. The program, therefore, has not been proceeding as fast as hoped, but it is providing employment and a paycheck to individuals who might otherwise be institutionalized.

Jim feels he has accomplished all that can be done at this time and resigns on June 31, 1976 to become an employee of Technical Development Corp. He will devote most of his time to designing new assistance programs. Jim will continue to counsel in housing planning and construction and in the restoration of old buildings and hotels.

Richard B. Marsten, '45, has recently been cited as one of America's "Adult Educators of the Year." The award was for his accomplishments in directing the design, development, launch, and use of the Application Technology Satellite 6 for N.A.S.A. Dr. Marsten was director of Communications and Data Management programs for N.A.S.A. before he was named Dean of C.C.N.Y.'s School of Engineering on September 1, 1975.

We have no new information regarding the 30th Reunion in June. Since this is the last issue before the Reunion, we again urge you to come. The reunions are great!

Arthur Y. Taylor, an older member of the Class of 1946, died in Marblehead at age 68. Mr. Taylor had graduated as a civil engineer at Union College before entering M.I.T. to complete his studies in electrical engineering. Mr. Taylor was a life Fellow in the Institute of Electrical and Electronic Engineers and had supervised design of thermal power, nuclear power, and particle acceleration projects, as well as test facilities for large industrial plants. Mr. Taylor had been President of Jackson and Moreland, Inc., a Boston consulting engineering firm, and more recently had been associated with Charles P. Main, Inc. of Boston. — **Russell K. Dostal,** Secretary, 18837 Palm Cir., Cleveland, Ohio 44126

47

Since this is spring and reunion time, let me open with a letter from **Claude Brenner:** "Like it or not, our 30th Reunion is a year from this June. Technology Days in 1977 will be June 9 to 12. Planning has already started and I'm writing to tell you that I've appointed **Don Van Greenby** to be Reunion Chairman. He is lining up a committee and I expect an appeal from him soon for Class Dues to finance the Reunion planning."

Not too long ago, June and **Arnold Judson,** and Jackie and **Ed Kane** joined Mary and I for a delightful evening. Jud is in the Management Group at Arthur D. Little. Ed is with Combustion Engineering in Stamford, Conn.

Oiva Anderson's wife, Annette, died last fall after a long illness. It was not the happiest occasion on which to meet classmates, but **Jack Hill** and Homer Eckhardt, '45, attended Annette's funeral.

K. Tebo is with the Continuing Engineering Education program of George Washington University. . . . Andrew Corry, '44, is Vice President/Electric of Boston Edison. He has been with Edison since shortly after leaving school working in several engineering and supervisory capacities. . . . **Albert Black** is now a Consulting Engineer at the Electromagnetic Systems Division of Raytheon in Goleta, Calif. . . . **Ken Block,** Chairman of the Board of A. T. Kearney, has been elected to a two-year term to the Conference Board of Chicago. — **Dick O'Donnell,** Secretary, 28516 Lincoln, Bay Village, Ohio 44140

49

As I set out to organize these notes, I am on a Pan Am 747, returning from Rio de Janeiro "permanently," several months earlier than my original schedule and in time to enjoy spring in New England, ensconced in our home in Concord.

First, news of some upwardly-mobile classmates. Last September, **John B. Sutherland** was promoted by GM's Fisher Body from manager of their fabricating plant at Lordstown to be general factory manager of Fisher Body metal fabricating plants in five cities. John started with Fisher Body in 1949 as a student-in-training, and has been climbing steadily ever since. . . . **Thomas R. Brown** indicates that he is president of Burr-Brown Research Corp. in Tucson, which an "industrial thumbnail" from the Tucson Desert Silhouette reports as employing 360 residents, having 6,000 customers worldwide and 1974 sales of over $12 million in "computerized process control systems, medical and analytical instrumentation, communication systems, navigation and guidance, aircraft and business machines." Whew! . . . **William S. Edgerly** was chosen last year as president of State Street Boston Financial Corp., the parent of State Street Bank and Trust. . . . More recently, in February, **Edward T. Thompson** was appointed Editor-in-Chief of *Reader's Digest* and was elected to the Board of Directors of the Reader's Digest Association, Inc. He has been with them since 1960. Congratulations all!

From Technology Fund Notes: **Joseph Sableski** reports: "For the past 11 years I have been with the Environmental Protection Agency or its predecessor agencies in air pollution control. Currently I am chief of a section that drafts E.P.A. regulations and guidelines. In December, 1975 I completed requirements for a Masters of Environmental Engineering from the University of North Carolina at Chapel Hill." . . . and **Edward R. Ardery,** in the graduate program in 1949, retired as Colonel from a career in the Army Corps of Engineers. He has since worked as construction manager for an engineering firm supervising the construction of the Washington Metro, as a Vice President for a small engineering firm, and currently as construction manager for the Potomac Electric Power Co. . . . A clipping from the *Harvard Business Review* indicated that one of the judges for the 1976 McKinsey Awards for best articles is **John S. Anderegg, Jr.,** listed as Chairman and President, Dynamics Research Corp.

Paul Weamer, Class President, reports that 1949 will as usual sponsor an Alumni Day cocktail party (this year with '47, '48 and '50) on Thursday, June 3, 5:30-7:30 in McCormick Hall, preceding Tech Night at the Pops. Plan to come. On a more personal note, he continues: "Virginia and I celebrated our 25th anniversary by participating in one of the XXV Century Club tours to Acapulco and Mexico City a couple of weeks ago. It was a marvelous time, even more wonderful because our schedule allowed us to participate in the Mexican Fiesta sponsored by the M.I.T. Club of Mexico City. Never have we had such a good time, or become so friendly with so many people at one time. This was their 28th Fiesta, and they certainly know hospitality and entertainment."

A clipping reports that Reverend **Lloyd Jonas** attended Fuller Seminary in California after seven years in research for M.I.T. and Corning Glass. Since then, he has been working full time as a pastor-counselor. In November, he presented a week-long seminar at the Bible Institute of New England on everyday counselling.

George H. Bradley, Jr. is National Watchman of Woodmen of the World. He is also a director of the Woodmen of the World Life Insurance Society of Omaha. A resident of Albuquerque, he and his wife Norma have four daughters and a son. . . . **Paul Weamer** has asked for more information on the Class of 1949 Visiting Professor for this academic year, Robert S. Morison: Bob Morison's career is in the biological sciences. A Harvard graduate, he taught physiology at the Medical School, worked with the Rockefeller Foundation, was Professor of Biology at Cornell and then founding director of the Biological Sciences Division there. He has been associated with the Institute of Society, Life Sciences, and Ethics, the Hastings Institute and the General Motors Science Advisory Committee. As Visiting Professor, Bob Morison intends to relate biological sciences to social problems, participate in M.I.T.'s Bicentennial Symposia and the Technology Studies Program, and develop a successful continuing Education Program.

We have been informed of the death of three classmates. **Peter Whoriskey** was killed in a six-car holiday-traffic accident in Willington, Conn., the day before Thanksgiving last November. He was working as a chemical engineer in New York and had moved to Acton, Mass., shortly before his death. Our condolences go to his wife, Phyllis, and their six children, Peter, 14, Neil, 13, Mary Phyllis, 11, Phillip, 9, Wendy, 8, and Katherine, 5. . . . **Edward M. Berly,** of Newton Highlands, Mass., died of a heart attack on September 9, 1975. During his career, he invented Micronaire, an air-cleaning process. Before his death, he had acquired the Samuel Ward Manufacturing Co., a Boston stationers and diploma-engraving company, and had expanded its production into the social book field. Our condolences go to his wife, Adele, and his two daughters, Mrs. Andres Hertz of Toronto, and Lauren.

I have a news clipping reporting the death of **Stewart William Sennett** on September 14, 1975, at the age of 53. At his death, he resided in Coffee Run Condominium, Hockessin, Del., and was senior patent specialist for the Engineering Physics Laboratory at the Du Pont Co. Experimental Station. He was also a member of the Delaware Association of Professional Engineers and was senior warden of St. Barnabas Episcopal Church. In 1957, he received the Order of the Beaver, the highest award in the Boy Scouts. He is survived by his wife, Marcia, two sons, Gary Stewart and Stewart William, Jr., his mother and a sister. Our

Why Shultz and Nixon Parted: Price Controls

George P. Shultz, Ph.D. '49, left the Nixon administration in 1974 because he was opposed to mandatory wage and price controls. He still is. "Wages and prices cannot be frozen for any length of time without creating massive distortions in the economy," he told a Janeway Lecture audience at Princeton late last fall.

Three kinds of problems come with wage and price controls, said Dr. Shultz, who is now President of Bechtel Corp.:

— Intense, short-term pressures — attempts, for example, to beat controls by raising wages and prices before restrictions take effect.

— The problem of applying regulations to a private sector which is at best reluctant. "Everyone says 'control everyone else but leave me alone'," Dr. Shultz said.

— The futility of anticipating every condition to which the controls will have to apply. Every exception for every special case is a step on the way to disaster, said Dr. Shultz: "One step leads you to the next step until one day you may not be standing near the desired spot."

Throughout his career heading the Office of Management and Budget and as Secretary of the Treasury, Dr. Shultz persisted in advising the President that using controls to slow inflation would be no bonanza. He is a "true believer," he told his Princeton audience, "in the doctrine that inflation, on the whole, is attributable to government." Dr. Shultz's conviction finally prompted his separation from the Nixon administration, says James T. Barron, Princeton '77, in the *Princeton Alumni Weekly*. "It was considered bad form to stand up and say you think controls are a lousy thing that should be ended," Dr. Shultz said.

George P. Schultz, Ph.D. '49, has no regrets about having resigned from the Nixon administration in 1974. "Even if I was a devilish fellow," he told a Janeway Lecture audience at Princeton late last fall, "I couldn't have devised a better thing to do." Watergate had nothing to do with it. It's simply that the wage and price controls on which Mr. Nixon insisted fulfilled every one of Dr. Schultz's dire expectations. Dr. Schultz's bachelor's degree is from Princeton, but the example of Princeton's mascot in the picture belongs to a San Francisco Zoo, and the picture itself was made for the zoo's purposes in Dr. Schultz's Bechtel Corp. office. (Photo: Princeton Alumni Weekly)

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heartfelt condolences to all relatives and friends of these three classmates.

I hope to see more and hear more of you, now that I am back in the Boston area. Best wishes to all. — **Frank T. Hulswit,** Secretary, Acorn Park, Cambridge, Mass. 02140

50

Mariano A. Romaguera was recently named member of the M.I.T. Educational Council for western Puerto Rico. . . . **Charles R. Faulders** is hard at work on applications of aerospace technology to advanced energy systems, such as coal's conversion to oil and gas, solar energy for household heating and cooling, and automating coal mines.

Jim Jensen missed the reunion because, at the last minute, he had to go on an overseas assignment. . . . **Thomas R. Eggert** formed a real estate brokerage business about a year ago and is engaged in industrial, investment and residential real estate. Tom welcomes all inquiries for Colorado real estate needs. . . . **Edward J. Young** is quite proud of his daughter, Ann, who has been ranked number one in Colorado tennis for girls 16 and under, for two years straight (1974 and 1975). . . . **Richard L. Bolin** has moved to Flagstaff from Mexico City, and is President of his own company, International Parks, Inc., which specializes in developing manufacturing free zones abroad.

Robert W. Furman is President of the Lincoln Engineering Co. in Maine. He was formerly associated with Cargocaire Engineering Corp. of Amesbury, Mass. During his years with Cargocaire, Bob traveled all over the world as the company expanded; he successfully met and overcame spoilage problems in a variety of industries. He did graduate work in naval architecture at Stevens Institute and served on oil tankers as a naval architect with Grace Lines before joining Cargocaire. He returned to Maine in 1972, and now lives in Pemaquid with his wife and two children.

Sydney Self, Jr., was one of three candidates interviewed for a position on the highway commission in Sudbury, Mass. Sidney is a systems analyst and has lived in Sudbury since 1960. . . . **Rex Anderson** is presently principal of Linenthal-Eisenberg-Anderson, Inc., Engineers of Boston. Rex and his wife live in Canton, Mass., with their two children. . . . **R. Stanley Bair** is partner-owner of Leifeste and Bair, A.I.A. Architects and Engineers in Houston, Tex. Stan is a fellow of the Construction Specifications Institute; member of the American Institute of Architects; registered architect; and registered professional engineer.

Peter B. Baker tells us that, after 20 years of working for others, he landed in the ranks of the professional unemployed in mid-1970 and took off on the development of his own business. With a partner, he formed a sales company (Baker and Malcom Co.), specializing in industrial flexible packaging. They have grown substantially in three and a half years and now hope to construct their own industrial polyethylene film plant. Their hopes and expectations for the future are bright. Peter says a marvelous wife and family are an essential part of the picture.

Fred Barker, research geologist with U.S. Geological Survey in Denver, Colo. has published 25 articles. Fred has been in Denver since 1962, working mostly on the geology and geochemistry of precambrian granites and other rocks of Colorado and Wyoming. He spends about three months of each year in the high mountains. He has begun detailed geologic mapping of the southern part of the Bighorn Mountains, northern Wyoming. Fred works out of a backpack camp; says it keeps the bodyweight and blood pressure down.

Mauricio Casanova Bazan has been President of Consultores de Ingenieria

Consulting, South America, of which he is a founding partner, since May, 1972. He is a co-founder of the School of Mechanical Engineering of the Central University of Venezuela, where he is a professor and former Head of the Department of Power Engineering. He is also Project Engineer of the School's Laboratory of Thermal Machines, and Instructor of Mechanical Drawing at the National University of Engineering in Lima, Peru. Mauricio has 33 technical publications in Venezuela, the U.S., and Peru.

Jay Bedrick is presently program manager of Hamilton Standard Division of United Aircraft Corp. in Connecticut. He has been married since 1955 and has one son and two daughters. Jay currently manages a variety of programs with activities in U.S., Canada, Brazil, Japan, Israel, and Ireland. . . . **Norton Belknap** joined Standard Oil Co. as an engineer upon graduation. He held various positions in organization until 1961 when he was transferred to Japan as senior managing director. Later he became Vice President of Exxon's Japanese affiliate. He spent 1966 to 1969 in Sydney, Australia, as Chairman and Managing Director of Exxon's Australian affiliate. From 1969 to 1973, Norton was based in London with Esso Europe, Inc., where he was responsible for operations in Belgium, West Germany, and The Netherlands. He became Executive Vice President of Esso Europe in 1971, and in 1973 he was named Vice President of Exxon Corp. with responsibility for corporate planning. Norton and his wife, Mary, have two sons and a daughter. . . . **Lowell S. Bensky** reports that after engineering and management positions with R.C.A. and Honeywell in computer product design and application, he spent several years with smaller companies in market and business planning and in operations. For the past five years Lowell has been an independent consultant with a practice devoted to high technology, product situations. Lowell and his wife, Janet, have three sons and live in Lexington. On summer weekends, they can be found on their 26-ft. sloop in the vicinity of Gloucester Harbor.

We regret to announce, the death of **Raymond Ghosn,** Dean of Engineering and Professor of Architecture at the American University in Beirut, due to an unfortunate accident on February 17. — **John T. McKenna, Jr.,** Secretary, 2 Francis Kelley Rd., Bedford, Mass. 01730

51

1951 25th REUNION! Reunion co-chairmen, **Dick Reedy** and **Jay Rosenfield,** have announced that our plans for the 25th reunion are now in their final stages. The program is an excellent one and indications are that we will have the all-time record M.I.T. reunion of any sort whatsoever!

Well over 200 classmates have indicated that they will attend. Nearly all are bringing spouses, and a great many are bringing their children for our 25th which is scheduled appropriately for the 1976 Bicentennial. Total attendance could exceed 600.

The reunion officially runs from Thursday evening, June 3 through noon on Sunday, June 6. Accommodations will be on the M.I.T. campus. Families are invited to arrive as early as Wednesday morning at no extra cost "except that you will be on your own for meals" — so this is a chance for a family vacation in Bicentennial Boston.

The reunion will open with a buffet Thursday evening followed by the incomparable Boston "Pops" with Arthur Fiedler playing just for M.I.T. at Symphony Hall. Friday will be Technology Day (formerly called Alumni Day) with panels of Institute speakers, and our record (we hope) 25th reunion gift to M.I.T. There will be a class dinner/dance Friday evening and a family clambake at the beach on Saturday. We will even have a German beerfest Saturday night complete with band. Sunday will be a quiet day.

All of our children are invited, at dads and moms expense, from ages 0 up to the maximum. M.I.T. will be conducting a program especially for sons and daughters. They will be completely on their own with counselors provided by M.I.T. The program was designed by a committee of sons and daughters of classmates who, together with current M.I.T. students, plan an incomparable way for our sons and daughters to see Boston and M.I.T.

In the meantime, reunion gift chairmen, **Howie Levingston** and **Breene Kerr,** are mounting the final push toward meeting our $1 million goal. If you have not yet pledged at or beyond your maximum, please do so.

Many of you who are former sailors will be hearing from **Gerry Marcus** who is spearheading a special $50,000 project within our class goal to make a class of 1951 wing for the soon to be renovated M.I.T. sailing pavilion. Gerry is anxious to hear from as many of you as possible. — **Fred G. Lehmann,** Director of the Alumni Fund, E19-439, M.I.T., Cambridge, Mass. 02139

52

It's hard to believe that the 25th reunion of the class of 1952 is only a little over a year away. In January, 15 class members met under the leadership of **Arnie Kramer,** Chairman of the Reunion Committee, to discuss with Joe Martori of the M.I.T. Alumni office possibilities for the reunion program. The meeting was held at Arthur D. Little, where our host was **Dick Heitman.** Most of the evening was spent studying the plans of the class of 1951, and examining the program they selected. The amount of support that M.I.T. offers to 25th reunion classes amazed all of us. All M.I.T. facilities are open to members of the class and their families, including the pool, the sailing pavilion, all educational facilities, and dormitory space. You'll be hearing from us throughout the year. The reunion is scheduled for June 8-12, 1977.

Because of the press of personal affairs, **Mike Nacey,** elected class President at our 20th reunion, has resigned. **Arnie Kramer,** as chairman of the 25th reunion committee, has assumed Mike's duties and is our interim president.

Nicholas J. Haritatos writes that he is in the chemicals design group at Chevron Research. Nick is working on six projects: two fertilizer plants, two pollution control projects, and two possible petrochemical projects for the Gulf Coast. He is also active in Cub Scouts and is helping raise his family. He has a son in the third grade and a daughter in the first. . . . **Dave Weiss** writes that he has been with Booz, Allen and Hamilton for over 12 years now, and was elected a partner in 1973. Dave is active in studies related to transportation, energy, and the environment. He has three children, a son who is a freshman at the University of Georgia, and two girls who will enter college in 1976 and 1977. Dave is still active as an Educational Counselor and fund raiser. . . . Another member of the Educational Council — for 16 years — is **Jack Larks.** "Besides interviewing prospective Tech students, we had an annual Wellesley/M.I.T. talk fest where vacationing students from both schools met future students and alumni."

James M. Margolis, President of Margolis Industrial Services, writes that he is living in New York City and has opened an office at 11 West 42nd St. to reestablish an industrial marketing consulting business in plastics and resins, petrochemicals and related energy fields. . . . Robert Astra (professional name of **Robert B. Astrachan),** Associate Editor of *Modern Materials Handling* magazine, has been named a member-at-large on the Board of Directors of the Society of Packaging and Handling Engineers. Bob is also Vice President, Publicity and Public Relations of the New England chapter of S.P.H.E. . . . **Dan Lufkin** writes that his solar energy consulting firm is moving along well. One of his designs for a solar-boosted heat pump system won an H.U.D. demonstration grant, and will be built soon. Aside from that, he is teaching physics and astronomy at Hood College and learning a great deal in the process. He is getting the observatory at Hood back into operation after several years of disuse. Back in the thirties, he writes, Williams Observatory did valuable variable-star work, but city lights (even those in Frederick, Md.) have limited the possibilities. The main instrument at the Williams Observatory is an eight inch refractor built in Cambridge about 100 years ago by Alvan Clark.

John M. Prizer returned in 1975 from a four year assignment in Belgium as a Controller of Ford Tractor Belgium, Ltd. Currently John is employed as Controller of the Romeo Tractor and Equipment Plant, Ford Motor Co., Romeo, Mich. He, his wife Margie, and six children are doing fine; although he notes that the middle class economic pinch hurts! . . . **Al Kandel** and his wife Fran both decided to switch careers three years ago (better than changing partners, which is so prevalent these days). Fran dropped teaching and is now in her third year of law school at U.C.L.A. Al dropped the aerospace industry and is a real estate broker specializing in income properties. Two of their three daughters are now in college. Wendy is a junior at the University of California at Santa Cruz; Adrienne is a freshman and Regents Scholar at the University of California at Davis.

The Continental Can Co. announces that **Jess L. Belser** of Westport, Conn., has been elected President of the Continental Forest Products Group and Executive Vice President of Continental Can Co. Mr. Belser has been Group Vice President and General Manager of Continental's Forest Products Operations. He joined the company in 1961 and served in various management positions in Continental's Metal Operations. . . . Hydrometals, Inc. of Dallas, Tex., announces that **James R. Reese** was elected by the Board of Directors to President and chief operating officer. Mr. Reese joined Hydrometals in 1968, following more than ten years of diverse management experience at Texas Instruments, Inc., including

Assistant Vice President and Operations Manager of T.I.'s Semiconductor-Components Division. At Hydrometals his first assignment was as president of the U.S. Brass subsidiary. During his six-year term, U.S. Brass more than doubled sales and established an important position in the single-control faucet market. He became Executive Vice President of Hydrometals in 1974. He and his wife Barbara have lived in Dallas since 1956. They have two children. — **Arthur S. Turner,** Secretary, 175 Lowell St., Carlisle, Mass. 01741; **Richard F. Lacey,** Assistant Secretary, 2340 Cowper St., Palo Alto, Calif. 94301

53

Ignore hereafter the adage "no news is good news." It makes for bad class notes coverage, and lousy jokes and puns. . . . **Jack Walsh** sent an almost indecipherable note; the unexpurgated but M.-Wohl-translated-version runs as follows: "Joined Borg Warner Corp. in 1961 after serving four years in the Corps of Engineers and three years in consulting. After various international assignments in New York, Chicago, and London elected President of the York Europe Division in 1969. Board member Borg Warner Ltd. [and ???]. Reside in Brussels with wife, Christine, and four children. Have spent 15 years in Europe since leaving M.I.T. [tough break, Jack!]. Hobbies: cross country, horse riding, skiing." . . . **Richard Ahrons** has been appointed MOS Systems Marketing Specialist at Motorola's Semiconductor Products Division. He is past Vice President-Engineering and cofounder of OPCOA Division of AVI Corp. and more recently Vice President-Operations for Innotech Corp. Prior to these two posts he spent 15 years with RCA, where he pioneered in such then-new semiconductor technologies as LSI circuitry, CMOS and MNOS circuits and processes, and LED and liquid crystal displays.

Paul Loewenstein is Vice President and Technical Director of Nuclear Metals, Inc., a company with which he has been associated since its inception; he started out with its predecessor, the Manhattan Project, at M.I.T. He is well known in metallurgical research and development for original work in practical fabrication of "exotic" metals and alloys for nuclear reactors and for recent advances in their adaptation to aerospace and industrial applications. . . . Sandi and **Fred Brecher** wrote, "Love your articles in the *Tech Review* and as each issue appears we know there will be something about the Class of '53 *even if you have to make it up.*" [More truth than fiction!] And they added, *to whoever is in charge* (who is it?), "Say — maybe you can tell us why we never received the picture from the last reunion!" . . . Carolyn and **Dick Lindstrom** reported on a "flying" vacation and business trip to North Carolina and Virginia a while back. Their family is growing tall and keeping busy with multitudinous interests. Daughter is a freshman in high school and son in the sixth grade. . . . I at least can say that — if Christmas cards serve as validation — Ann and **Bill Gilbert** and Susan and **Tom Faulhaber** are "alive and well." . . . **Howard Martin** writes that "after three and a half years with the frustrating liquefied-natural-gas business, I am leaving Cabot Corp. and moving to Kay-Fries Chemicals in Stony Point, N.Y. As Senior Vice President for this manufacturer of organic intermediates, I hope to see it grow and diversify.

"We'll be moving after the [1975] holidays [from Wellesley Hills] to the Rockland County, N.Y., area, which is almost midway between Kathy at Bucknell and Dave at Williams." . . . All for now, more "Christmas card reports" next month. In the meantime, please do swamp me with news. — **Martin Wohl,** Secretary, 7520 Carriage Ln., Pittsburgh, Penn. 15221

54

Nick G. Markoff is living in Evanston, Ill., with his wife, Mary, and two sons, Stephen and Matthew, and working in Pallatine. . . . **Dale Roff** says he wants to surface after 20 years of silence. He would like to reestablish communications with **Caso, Brown, Christie, Hoppenfeld,** and Kerr, '55, and he invites any of his other former classmates at M.I.T. to be in touch with him (Box 1248, Albuquerque, N. Mex., 87103). Dale is working in the Bureau of Indian Affairs and finds it very challenging considering he is a non-Indian.

Paul Stern is Vice President and Resident Manager of the Los Angeles office of Codwell Banker Commercial Brokerage Co., lives in Tarzana, Calif., with his wife, Marilyn, and three children, and is a member of the M.I.T. Club of Southern California and the Harvard Business School Association of Southern California. . . . **Scott Mudgett** believes he has a first for the Class of '54: he officially retired from the U.S. Army on October 7, 1970, and then returned to the Sloan School at M.I.T. to earn his master's degree in management. He is now into a second career; retailing, as Director of Real Estate for Ayr-Way Stores, Inc., a $150-million regional chain. Look for the Ayr-Way Special in the Indianapolis 500 race in May.

"Old Man" **John Bradshaw** proudly announces that he and his wife had a 21st anniversary baby, a little girl, Catherine Pilcher, on May 24, 1975. They now have three children. . . . **John C. Hagen** is serving as Manager of Geology and Exploration for the Hanna Mining Co. in Brazil; he was recently appointed Director of Dragagem Fluvial S.A., a Hanna-Brazilian company, which is exploring for diamonds and gold. . . . **Ken Heist** is living in Manhattan Beach, Calif., with wife and two children, aged 7 and 9. Ken works on satellite communications for TRW.

Paul Goncz is on a two-year tour of duty with the U.S. Army in Germany as a battalion commander. While Paul is overseas, brother **John** is occupying his home in the Washington, D.C., area and is working at Teledyne-Geotech. As you may remember, John emigrated to Australia a few years ago, where he earned his doctor's degree in geophysics. He also met **Hossein Nasr,** who teaches at Tehran University in Iran. . . . **Wally Boquist** reports that **Ray Freeman,** who works for the Army in the Washington, D.C., area, was recently married and that **Don Dix** works for the Institute for Defense Analyses there.

O.K., classmates, **Marlen Miller** suggests we say thanks to our professors of yesterday, and we agree with him. Our success is, in turn, their success — although we grudgingly admit it many years later. So let's hear from you as to the professor or instructor you remember best. If you remember after all these years, he must have been good! Already votes are in for the late Francis W. Sears, "the drawer of the perfect circle," and good ol' Jack Rule — the friendly dictator of Course IX. Marlen Miller remembers Professors Rohsenow, Shapiro, J. Clark (now at the University of Michigan), and Griffiths (his former roommate). Who do you remember? Write one of us with your favorite and give a reason or two.

Remember, 1954 to 1979 is 25 years and we want to do something for M.I.T. to remember us by. We have put aside suggestions to paint the grand dome yellow, fly the confederate flag from the great hall, and put a 1901 Ford in room 301 of Hayden. Any other suggestions? — **Dave Howes,** Secretary, Box 66, Carlisle, Mass., 01741; Assistant Secretaries: **Chuck Masison,** 76 Spellman Rd., Westwood, Mass., 02090; and **Lou Mahoney,** 6 Danby Rd., Stoneham, Mass., 02180

56

Our 20th reunion — fabulous is the word — is almost here. Dormitory accommodations in McCormick Hall are available for Thursday, Friday, and Saturday, June 3, 4, and 5. The Committee met in March, selected reunion gifts, and made final plans for cocktail parties, dancing, and a delicious weekend menu that includes an elaborate buffet on Friday night and a roast rib dinner Saturday night. A block of 100 table seats for M.I.T. Night at the Pops is being distributed on a first-come basis. Lobster and chicken, kegs of beer, swimming, boating, tennis, frisbees and ball games will be parts of the Saturday outing. Registrations from only the first mailing included 45 classmates, 38 spouses and 36 children, or 0.8 children per classmate! You can still join us if you act immediately. A copy of the Reunion questionnaire results will be the reward of paying class dues. Direct all correspondence to: **Martin Reiss,** Gamewell/Alarmtron, 91 Bartlett St., Marlboro, Mass. 01752. For other information, call one of the following area representatives: Detroit — **Herb Amster;** Northern California — **Roger Borovoy;** New York — **Walt Frey;** Connecticut — **Murray Gerber;** New Jersey — **Irwin Gross;** Washington, D.C. — **Larry Moss;** Chicago — **Max Plager;** and Southern California — **Clark Weissman.**

Paul Abrahams, on sabbatical from his job as Associate Professor of Computer Science at N.Y.U., is spending a year in western Massachusetts writing, thinking, and recovering from New York City. . . . **Larry Blodgett,** Director of Engineering for Chesebrough-Ponds in Connecticut, attended the Chemical Engineering Convocation in March; he was formerly with a subsidiary of National Patent Development and in his own firm.

Stanley Hart joined the M.I.T. faculty last July as Professor of Geology and Geochemistry. His specialty is the study of geochronology and isotope geochemistry to determine the evolution of the earth's mantle. . . . **Rusty Schweickart** is Director of User Affairs at N.A.S.A. in Washington while he waits for the space shuttle to get off the ground. . . . About seven years ago,

Members of the Class of '57 meet at a New York-area cocktail party: (left to right)

Richard Monsen, George Beerli, host Ed Friedman, Milton Lilie, and Richard Bumby.

Nick Wise established Technology Products Group, which acts as manufacturers' representative for electronic components. He is active in town government, recently appointed a member of the Brookline (Mass.) Rent Control Board. — **Bruce B. Bredehoft,** Box 181, Dover, Mass., 02030; Mrs. **Lloyd Gilson,** 35 Partridge Rd., Lexington, Mass., 02173, Cosecretaries.

57

Here are some notes on the New-York-area class cocktail party hosted by **Ed** and Arline **Friedman** at their lovely home on the campus at Stevens Institute in Hoboken, N.J., on February 6. Their home is interesting because of the marvelous view overlooking the Hudson River to New York City and because it is decorated with many items acquired during stays in Afghanistan. On this page are photos which **John Spencer** took during the dinner that followed at the Clam Broth House in Hoboken.

Among those present: **Milt Lilie** reminds us that he is one of a small minority doing "real engineering," working on laboratory automation at the I.B.M. Thomas J. Watson Research Center in Yorktown Heights, N.Y.; but he has interrupted this temporarily to work with the legal staff on the government anti-trust suit. He comments that he and his wife, Tish, and their two children "have long since found that good friends, good books, and good music far outweigh the mortgage and breaking appliances." . . . **Joe Cohen** and his wife, Barbara, live in Short Hills, N.J., with their two sons. Joe has an M.D. from New York University and specializes in cardiovascular and thoracic surgery at St. Barnabas Medical Center, Livingston, N.J.; he is Clinical Assistant Professor of Surgery at the New Jersey Medical School, College of Medicine and Dentistry of New Jersey. Others who attended the party included **Dick** and Janet **Monsen, Dick Bumby** and his wife, and **Jordan Gruzen.**

A press release informs us that **Andrew Viterbi** has received the 1975 Christopher Columbus International Communications Award, given annually by the City of Genoa, Italy, upon the recommendation of an international committee selected by the Italian National Research Council. Andrew is presently Executive Vice President of Linkabit (research, development and manufacturing of advanced communication coding and modulation equipment for satellite and terrestrial communication applications), of which he was co-founder in 1968. . . . **Jim Alstrom** and his family are still in Farmington, Mich., where Jim is working for Burroughs Corp. as Manager of Engineering Operations for Mini-computer Systems. This winter he has been teaching his two sons to ski; during the summer they enjoy sailing on lakes in the area. Jim has progressed about half way towards his Ph.D. in accounting and information systems at the University of Michigan. . . . **Ralph Warburton** was elected Chairman, in June, 1975, of the Architectural Engineering Division of the American Society for Engineering Education; he is on the Education Advisory Committee of the Florida State Board of Architecture and on the task force on core curriculum of the American Society of Landscape Architects. With all of this, he continues teaching and consulting in architecture and planning.

Another press release: Handy and Harman has appointed **Don Corrigan** as Director of Metallurgy and Research. Don has been serving as Manager of Development since joining the company in 1973. . . . **Guy Carbone** will seek office as Selectman in 1976 in Watertown, Mass., where he has lived all his life and was first elected to public office in 1965 as a Democratic candidate for School Committee. Guy is currently senior attorney to the Department of Labor and Industries, Commonwealth of Massachusetts, and a Special Assistant Attorney General. Guy's platform: "Ribbon cutting and other public relations cosmetics make good copy, but they do nothing to help the 13 or 14 per cent unemployment in our town or restore the respect and confidence of the voters in their elected officials."

As always, it would be great to see or talk with anyone who is coming through New York. My telephone numbers are: business (212) 977-8655 — home (212) 865-1732. — **Fred L. Morefield,** Secretary, 285 Riverside Dr., New York, N.Y. 10025

59

A very small mailbag this month. If the new postal rate has gotten to you, why not try a postcard!

Gary Bracken has moved to London as Director of Engineering for the Williams International Group, which does worldwide engineering and construction of pipelines and related facilities. He and his wife, Nancy, live in London with two of their sons, who attend the American School in London. Their oldest son is a student at the Missouri Military Academy and visits London on holiday and summer vacations. . . . **Thomas McCabe** was recently appointed Advanced Projects Director in the Operations area for New England Gas and Electric Service Corp. Tom, who lives in Concord, has been with the company since 1963, after serving as an officer in the Navy. . . . Bruce Silberg, '60, who lives in Weehawken, N.J., has a short commute to the Association for Computing Machinery in Manhattan and is continuing education at The New School and N.Y.U.

It only takes a few minutes to drop a note to **Phil Richardson,** 180 Riverside Dr., New York, N.Y. 10024; **John Amrein,** 770 Greenwood Ave., Glencoe, Ill. 60022; **Adul Pinsuvana,** 49 Seri Rd., Seri Village, Hua Mark, Bangkok, Thailand; **Bob Muh,** 907 Chantilly Rd., Los Angeles, Calif. 90024; or **Allan Bufferd,** Secretary, 8 Whitney Rd., Newtonville, Mass. 02160

60

Susan Schur recently delivered a talk entitled, "There's Nothing New Under the Sun (Or, What's Happening Now Happened Then)" to the M.I.T. Club of Boston. Sue's own accomplishments suggest otherwise, including her position on the publishing board of *Technology and Conservation,* a new magazine concerned with the technical aspects of conservation and restoration of art, architecture, and antiques. Sue heads her own advertising agency, which specializes in technical and industrial accounts, has worked as a research metallurgist, and has been active in several professional organizations.

Linda Sprague currently is an associate professor in the Whittemore School of Business and Economics at the University of New Hampshire. Her husband, **Chris Sprague,** is visiting professor at the Boston University School of Management, on leave from the Wharton School. . . . **Sherman Karp,** senior engineer at the Naval Electronics Laboratory (San Diego), is co-author of the book, *Optical Communications.* Sherman, who received his Ph.D. from U.S.C. in 1967, has served as co-editor of two I.E.E.E. special issues on communications and as co-chairman of the Joint N.A.S.A./M.I.T. Workshop on Optical Space

Communication. . . . **Robert Crossley** is an Air Force test director at the Arnold Engineering Development Center (Tennessee). Bob earned his Ph.D. at Purdue, also in 1967. . . . **Herbert Fox,** of the New York Institute of Technology, has been named chairman of the Technology Assessment Panel of the Engineers Joint Panel. The panel works with the Office of Technology Assessment and other federal agencies to provide technical background for current legislation. . . . **Kearny Hibbard** has married the former Adair Jones in Old Bridge, N.J. Kearny is treasurer of the Thomas & Betts Corp. in Elizabeth.

And our daddy-of-the-month award goes to — *Me*! Christopher Ewing Stengel was born on what was formerly known as Lincoln's birthday, arriving via natural delivery at 10 lb., 1 oz. Pegi and I are pleased that he is developing well, and Brooke (age 7) is delighted to be a big sister. Class of 1997? I'm not sure — so far, he's a little slow on calculus. — **Robert F. Stengel,** Secretary, 152 Oxbow Rd., Wayland, Mass. 01778

62

Barry Roach, wife Kathy, and Molly (age four months) returned in January to Atherton after over three years in Mexico City. They are living close to brother John, M.I.T. 1965, and his family. He is continuing to work as partner in McKinsey, with some ongoing involvement in Latin American practice. . . . **Richard B. Anderson** is currently directing the National Analytic Evaluation of the Follow Through Program for Abt Associates, Inc., Cambridge, under contract to the U.S. Office of Education. His sixth child is due in May. . . . **Tony Mack** recently received a U.S. Patent (3,924,100) for a hot food cart which his company, Sweetheart Plastics, feels will revolutionize hospital feeding. The patent was featured in the *New York Times* "Patents of the Week" column on December 6, 1975. The invention consists of food serving trays containing isolated heaters, which keep hot food hot, when the tray is pushed onto racks in a special battery-operated cart. . . . **Robert A. Mayers** is a partner in the firm of Mayers & Schiff, Architects/Planners in New York City. They have been involved in the design of housing, educational, health, recreational, and commercial facilities. Projects have been located in Bangladesh, Latin America, Africa and throughout the U.S.A. He received the Bard Award for Merit in Civic Architecture and Urban Design in 1975 from the City Club of N.Y. and the Citation for Excellence in Design of Educational Facilities, 1975, from the N.Y. Chapter, A.I.A. He is presently teaching design studio at The Pratt Institute.

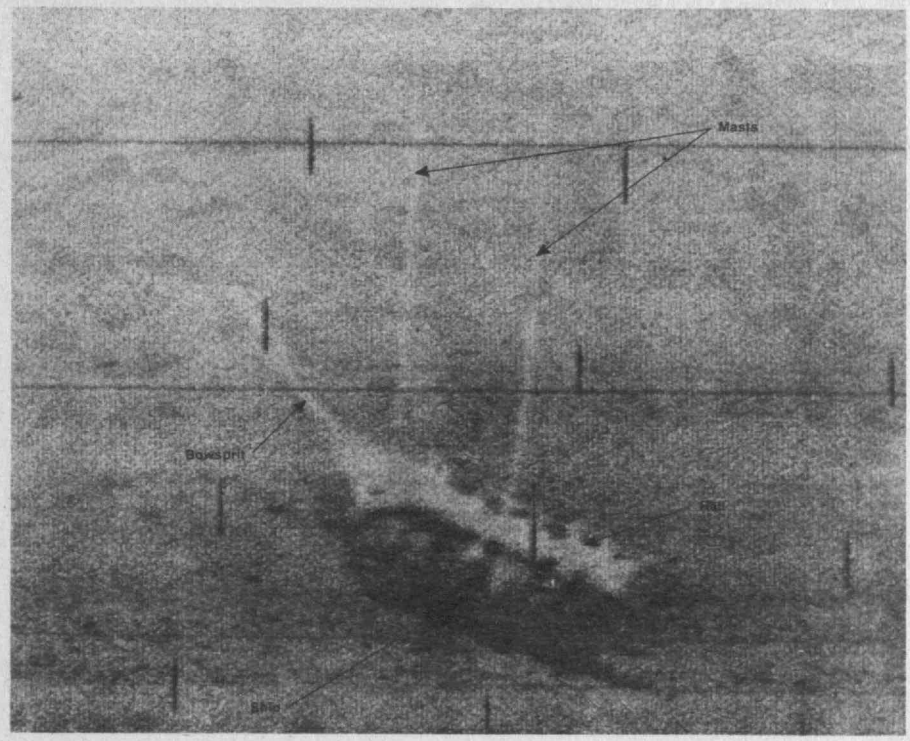
W. Thomas Brydges III has been appointed Business Planning Manager, Finance Division, of Corning Glass Works. He has been with Corning since 1968. . . . **William H. Anderson** has been appointed Assistant Professor of Psychiatry at the Massachusetts General Hospital. . . . **Martin Klein** writes that his company, Klein Associates, Inc., celebrates its eighth anniversary this year. They are leaders in the field of ocean exploration instruments and their equipment is used around the world to survey the sea floor. He is involved in the search for the Loch Ness monster. In December of 1975, he participated in an address to the House of Commons in London, presenting evidence for the existence of the monster. His wife, Diane, is a student at New England School of Law and they are now in their second 300-year-old house. — **Gerald L. Katell,** Secretary, Parking Structures Int., 250 E. First St., Los Angeles, Calif. 90012

63

John Hornstein received his Ph.D. in physics (elementary particle theory). He works for Computer Sciences Corp. in Silver Spring, Md., writing programs to help interpret data gathered by radio astronomy satellites. . . . After seven years and a Ph.D. at Georgia Tech, **Robert Mason** began working full time for Metrics, Inc., a consulting and research and development firm. . . . **John Brach** is also in Georgia, and is now a project manager with MARTA, the transit authority in Atlanta. His responsibilities include design and construction. John finds few people in Atlanta willing to admit that there *may* be an excellent school of technology other than Georgia Tech.

Steve McClure, his wife Donna, and their two children, Heather, now six, and Thomas Jefferson, almost two, live in Newton, Mass. He still works for Honeywell Information Systems, currently as a research and development Project Manager for terminal development. . . . **Terry Foster** has left his position as vice president of H.D.R. Systems, a computer timesharing company, to start Systems Consultants, Inc., a computer consulting firm. . . . **William Baugh** has been working on applications of classical control theory to the study of arms races. He gave his first paper on the subject at an N.S.F. Conference on Control Theory in International Relations Research at Indiana University, in April, 1974. His second paper was presented in Boston last February 21, at the A.A.A.S.

Richard Titus received his Ph.D. last November from Penn State in the field of man-environment relations. **Bernard Beaudoin** has been appointed director of economic planning for New England Power Service Co., a subsidiary of New England Electric System of Holliston, Mass. After his B.S.E.E. and M.S. from the Sloan School, Bernard joined New England Electric in 1965. He was named project manager for information systems planning in 1968. In 1970 he was appointed supervisor of management sciences, and was named manager of that department in 1973. Bernard lives in Holliston with his wife Jeannine and



Discovery of two important shipwrecks — the Hamilton *(left) and* Scourge, *American schooners sunk by a violent squall in Lake Ontario during the War of 1812 — is the latest archeological triumph of "Hydroscan," the side-scan sonar equipment designed and built by Klein Associates, Inc., of Salem, N.H. Dr. Daniel Nelson led a research team from the Royal Ontario Museum and the Canada Center for Inland Waters which found the two wrecks about 1,800 feet apart some 15 miles west of the Niagara River in 300 feet of water; he calls it "an amazing find." The sonar revealed the ships to be in remarkable condition — "upright on the bottom, guns on deck, with the masts, spars, and bowsprits still in position," says Dr. Nelson. The sonar, designed and built by a firm headed by Martin Klein, '62, who was also a principal in efforts to photograph the Loch Ness "Monster" (*see March/April, pp. 25-40*), produces a narrow sound beam which creates an acoustic shadow to bring out underwater detail.*

their three children. . . . **Jon Clemens** has been named Group Head, Signal Systems Research, at RCA Laboratories in Princeton, N.J. Jon received B.S. and M.S. degrees from M.I.T. in 1963 and a Ph.D. (E.E.) in 1965. Since then he has been with RCA, working on the development of RCA's "SelectaVision" VideoDisc system for playback through home TV sets of prerecorded television programs. Jon and his wife Arlene live in Skillman, N.J., with their three children, Terri, 12, Gina, 9, and Steven, 6.

Robert Purdy presented a paper on a digital signal processor design for radar applications at last November's I.E.E.E. Aerospace and Electronic Systems Chapter in Boston. Bob has been at Lincoln Labs since 1968. All these stable people — with the same companies for eight, ten, eleven years. — **Mike Bertin,** Secretary, 18022 Gillman St., Irvine, Calif. 92715

64

Greetings, '64, ... and GLURP! Would you believe just one class note this trip. Just ONE, and not a single class hero to boot. I guess I'm going to have to fake it.

For openers, we'll elevate our one, single, solitary press release to full coverage status, so **Richard N. Boyd,** here goes. Richard N. Boyd, Associate Professor of Philosophy in the College of Arts and Sciences at Cornell University since 1972, has been awarded tenure as of February 1, 1976. He came to Cornell from Harvard University, where he had taught for four years, having held previous appointments at the University of Michigan and the University of California at Berkeley. He earned bachelor's degrees in humanities and mathematics, completing his Ph.D. in Humanities in 1970, all from M.I.T. Dr. Boyd is a specialist in philosophy of science and has helped develop an undergraduate course on the history and the philosophy of biology. He is currently writing books on scientific realism and on materialist theories of the mind.

I hadn't heard from **Mike Monsler** for a while, so I called SAI to see how he was and what was happening with his move to Washington. Well, I guess Mike changed his mind about Washington. I hear that California is his new destination now. Good luck, Mike. Let's hear from you.

Marlene and I have made our commitment to the Washington area. Last month we bought a home near where we're living now. We won't be moving for several months, so don't change the address to which you send all that mail (mail?) yet. I'll let you know next month. By then, all our plans should be firmed up. For now, call us at (301)-340-7373 and WRITE. — **Steve Schlosser,** Secretary, 12401 Bobbink Ct., Potomac, Md. 20854

65

Hank Lichstein sent an aerogram bringing us up to date on his travels. Janine and Henry have been married eight years and have two sons, Daniel, 5, and Alexander, 2. The Lichsteins moved to Nairobi, Kenya, in December, 1975, when Hank became Regional Treasurer for Citibank, responsible for Citibank's activities in 47 SubSaharan African countries. A lot of travel is involved (the letter was on stationery from a Seychelles hotel and posted in Hong Kong!) Janine is a proficient rider and is thinking of starting a ballet school. Hank notes that their Nairobi house has guest quarters.

John Holdren made the *San Francisco Examiner,* testifying about the California Nuclear Safeguards Initiative; John is a professor at University of California at Berkeley. . . . **Steve Lipner** conducted a seminar on computer security at MITRE last December. . . . **Michael Gabel** is Assistant Professor of Mathematics at Purdue; the Gabels have a 3-year-old son and another child on the way. . . . Lilian and **Dave Carrier** spent a "summer Christmas and New Years" in Brasil with Lilian's family; the Carriers have one child, Bettina, 7. . . . **Carl King** has joined five other lawyers to form the law firm of Goldstein and Manello in Boston. . . . **Craig Wheeler** writes that he is "still in Austin spreading the gospel of neutron stars and black holes to the youth of Texas." . . . **Chuck Seniawski** was promoted to Major in the U.S. Air Force last December.

Lou Kleiman spent the ten years after graduation in Boston with various government agencies and working towards his doctorate. After getting his Sc.D. in Aeronautics and Astronautics in June, he left to become director of the Washington office of S. Ross and Co., consulting engineers. . . . Carol and **John Larkin** are now living in Lubec, Maine, where John is Pastor of the Lubec Congregational Christian Church. . . . **Herbert Mower** is now on the staff of the New England Medical Center Hospital's Department of Therapeutic Radiology; the Mowers (John, Frances, and Elizabeth Ann, 3) live in Arlington. . . . **Gary DeBacher** has been appointed assistant professor of physical medicine at the Woodruff Medical Center of Emory University in Atlanta.

The latest additions to the Hoffer family have been three hamsters, much to the delight of Jed, 5. Bruno, the Class of '65 honorary St. Bernard, has not noticed their arrival, fortunately for the mental health of the hamsters. — **Edward P. Hoffer,** M.D., Secretary, 12 Upland Rd., Wellesley, Mass. 02181

67

Has it really been almost nine years?

Robert Dann spent 1972-73 in Madrid and has since been teaching in the Boston area. At last report he and Mady were expecting their first child and were planning to move to Philadelphia, where Bob will be a research associate in radiology at the University of Pennsylvania Hospital. Bob has had several photography shows in the Boston area. . . . Cathy and **Don Bellenger** have a new house in Gaithersburg, Md. Cathy works for Senator Scott. . . . In March of 1975 **Alan Kruse** married Rita Page of Hazelhurst, Miss. A San Diego honeymoon followed the Tucson wedding. . . . **Ted Nygreen** writes: "Lacking any recent achievements worthy of public disclosure (or exposure), I can only report the status quo. I am still living in Princeton, working for NBC in New York City, and flying my airplane everywhere on weekends. Incidentally, we just had our second child, another girl, named Kysa. I guess I've always been partial to girls."

Jeff Schoenwald has moved from Texas Instruments in Dallas to Teledyne in Palo Alto, Calif., where he is a senior engineer working on surface acoustic wave devices. On March 20 Jeff married Sheri Finkelstein of Dallas and the University of Texas. In April he spoke at an I.E.E.E. Symposium in Munich. . . . Nancy, Michael, Amy, and **Bob Gerstle** have settled in Longmeadow, Mass. Bob is practicing pediatrics in Springfield and Wilbraham. . . . John Patterson, '65, writes: "I've been recently transferred to Fleet Tactical Electronic Warfare Squadron 33 at NAS Norfolk. I fly A-4 aircraft (Skyhawks) to provide electronic warfare training to fleet units, and we deploy periodically to San Diego, Jacksonville, Puerto Rico, and other exciting (?) places. Suzie and I have bought a home in Virginia Beach and are just getting settled."

During the last few months of 1975 **David Hill** was a member of the Governor's Management Task Force of the Commonwealth of Massachusetts. . . . **David McMillan**'s System Engineering Department at Tracor is flourishing. Dave hopes to see some Phi Delts during the Bicentennial. — **Jim Swanson,** Secretary, 669 Glen Rd., Danville, Calif. 94526

68

Greetings again as spring comes to the Washington area. The weather here can be as unpredictable as in Boston — as high as 83° this winter, and a few days later the wind-chill factor was 0°.

On with the news. . . . Reading through *Tech Talk* recently, we came upon a picture (*right*) of our own **Louise Silver** giving a cooking demonstration. The article explained how Louise and **Karen Brothers** taught a course during the Independent Activity Period in the New House dorm on "Cooking: Good, Easy, and Nutritious." Louise and Karen also run a computer-based nutritional analysis company, Consultus, Inc., using a PDP-8 in the Brothers' den. Clients have included newspapers, nursing homes, and individuals. . . . **Lissy Quinlan** has also been in the M.I.T. news: in January she was promoted from Research Associate to Assistant Professor in the Mechanical Engineering Department. She also holds an appointment at Harvard as Lecturer in Environmental Engineering in the Division of Engineering and Applied Physics. . . . Also from Cambridge, **Ken Theriault** writes that he hopes to finish his doctorate in Course VI in about a year ("bloody well about time"). He is looking forward to the end of school and "the beginning of a slightly more decadent lifestyle."

Closer to home, **George Kraus** is attending school in Washington and expects to be stationed here at least a year after he finishes in June. His wife, Judy, and one-year-old daughter, Lisa Ann, seem pleased to see him more often after more than three years of sea duty. . . . **Jim Berry** and his wife Lee Anne have settled and begun a joint practice of medicine in Dover-Foxcroft, Maine. Jim received his M.D. from Temple while Lee Anne graduated from the Medical College of Pennsylvania. They had previously practiced in Flemingsburg, Ky. . . . From San Francisco we hear that **George DiGioia** is Director of Food Technology with the Straw Hat Pizza Restaurants Division of

Louise Silver, '68, shows the magic of cooking during a course in the M.I.T. Independent Activities Period in January on "Cooking: Good, Easy, and Nutritious."

Saga Enterprises. George and Toni have two children and love sunny California.

Tom Terwilliger has been appointed Research Assistant Professor of Chemistry at Wright State University, Dayton, Ohio. He previously worked with Systems Research Laboratories in Dayton. . . . California may be nice, but **Phil Weidner** seems to prefer Anchorage, Alaska, where he is a trial attorney and appellate attorney for the Alaska Public Defender. With him are his wife, Maria, a teacher, and their 8-month-old daughter, Ana Cristina.

That's all we have this month. Drop us a note and you too can have your name in print. — **Gail** and **Mike Marcus,** Secretaries, 2207 Reddfield Dr., Falls Church, Va. 22043

70

Greetings from the midwestern correspondent, who has been relatively silent over the past several years. **Jim Bronfenbrenner** claims he is preventing the impending overthrow of society by the computer — à la Vonnegut's *Player Piano.* Jim further hopes M.I.T. is doing a good job of "humanizing" its engineers. . . . Graduates active in the Boston area know **Mary Thornton** has been a reporter for the *Boston Globe* for two years. Mary is now assuming new duties as a member of the special *Globe* spotlight team.

M.I.T. and the military is a relationship pursued by Major **Joseph G. McCoy, Jr.** He recently completed a four-year tour of duty with the U.S. Army in Europe. During his tour, Joseph was Chairman of the Alumni Fund of Germany, and Educational Council Representative. He continues in the Council in the Fort Huachuca, Ariz., area. . . . **Janet Mertz** has completed her Ph.D. in Biochemistry at Stanford and is now a post-doctoral fellow at the Medical Research Council of Molecular Biology in Cambridge, England. This fall she will be Assistant Professor at the McArdle Laboratory for Cancer Research at the University of Wisconsin. . . . **Marybeth K. Rupert** continued her education at Gordon-Conwell Theological Seminary, Georgetown University, and Yale, amassing three masters and one Ph.D. in American Studies. The past two years, she has been an Assistant Professor of Religion at Central Michigan University. In May, Marybeth starts in a new position with Tracor Jitco, Inc. of Rockville, Md.

Robert A. Dennis was the Budget Division Director of the Human Resources Administration of New York City. Recently, he joined the Board Department of the Boston office of Scudder, Stevens and Clark, an independent investment counseling firm. . . . Professor Forrester's *Urban Dynamics* has been embellished by *Readings in Urban Dynamics, Volume 2,* edited by **Walter W. "Chip" Schroeder III.** Chip is working with the Subcommittee on Energy and Power of the U.S. House of Representatives. . . . **Jacobo Schuster** left his work as a sales representative and system engineer for I.B.S. of Mexico to become an honors student in the M.B.A. program at Harvard Business School.

Jerry Kleinbaum, a senior medical student at Tufts, won membership in Alpha Omega Alpha, a medical honor society. Jerry is married to Nancy Horowitz Kleinbaum, former managing editor of a Melrose newspaper; they have one child, Stacey Michele. . . . Finally received some news on **Nicholas V. Mumford III.** Nick was promoted by Burroughs Welcome Co. in North Carolina to Production Planning Supervisor on the Production and Inventory Control Department.

Cincinnati remains the home of several classmates. **Terry Michael,** besides playing hockey with **A. M. "Sandy" Harlow** in the Proctor and Gamble company league, engages in brand management, and repair of his new house on Altview. Terry and Bonnie have a 1-year-old daughter, Carolyn. Down the street, Sandy and Marilyn have also just bought a house. Sandy is in the management systems division at Proctor and Gamble, while Marilyn works for the metropolitan police department in the special assignments division. . . . **Carl Yankowski** has left Proctor and Gamble to be Products Manager at Memorea Corp. in Santa Clara. He has world responsibility for Memorex tapes. . . . **John Holding** continues to work for a management consultant firm in Chicago. He's married and living in Evanston.

Now it is my turn. After some work at New England Merchants National Bank, I traveled to Bloomington, Ind., for law school. I enjoyed the educational institution's contrasts and the Hoosiers' basketball team. I clerked for a local judge for two of my three years in school. Upon graduation, I accepted an associate's position in Fort Wayne with Kennerk, Dumas, Burke and Backs. I particularly enjoy the litigation involved in products liability and professional liability. — **Robert Owen Vegeler,** Secretary, Kennerk, Dumas, Burke and Backs, 2120 Fort Wayne Bank Bldg., Fort Wayne, Ind. 46802

71

Tom Milkie is through with two years in the army, and is now with Aeronutronic Ford in Newport Beach, Calif., working on computer simulations of new defense missile systems. He met Ken Swick, '69, a technical manager for On-Line Systems out of Bala Cynwd, Penn., and also ran into Steve Schuster, '72, who works at Rockwell International in Anaheim. Trip Barber, '73, was in town to attend an A.I.A.A. symposium on rocket propulsion. Tom has been flying hang gliders for the last two years and is now building one of his own design. His wife, Judy, has kept up her training for long distance running and now runs 15 miles a day. She ran with a women's team from Hollywood to Las Vegas (relay) last year and hopes to compete in marathons this year. Tom's address is 5645 Ave Vinedos, Anaheim, Calif. 92807. . . . **Michael Allen** graduated from Stanford University in June, 1975 with degrees in law and business (JD-MBA) and finished in the top ten per cent of the class. He is now working as a consultant in the Chicago office of McKinsey & Co., management consultants.

Robert D. Marshall, Jr. is halfway through law school at Georgetown University. Last summer he worked as a legal clerk in the patent counsel office of N.A.S.A.'s Goddard Space Flight Center in Greenbelt, Md., and expects to be there again this summer. . . . **Jeffrey Millman** received his Ph.D. in Electrical Engineering from M.I.T. in September, 1975. He's now working at Lincoln Laboratory in the Radar Systems Group. He and his wife, Debbie, live in Woburn, Mass. . . . **Mike Gilmore** writes," I am serving fair notice on everyone in the country with whom I have had even a nodding acquaintance that sometime next summer I am embarking on a one or two months cross country drive during which I intend to visit (translate: free-load off) every Burton Third Bomber who has had the misfortune to put his name and address in the phone book. Anyone who has not contacted me at the Idaho Supreme Court within 20 days of this publication to tell me this is unacceptable will be presumed to have waived his right not to feed and house me."

Alan J. Grodzinsky, Assistant Professor of Computer Science and Electrical Engineering, has been appointed Esther and

Peter W. Hwoschincky, '71, (center), is presented the first William E. Jackson Award of the Radio Technical Commission for Aeronautics of Washington, D.C., for his thesis on the OMEGA navigation system for general aviation. He and his thesis advisor, Professor Walter M. Hollister (left), are congratulated by Professor Rene H. Miller (right), head of the Department of Aeronautics and Astronautics at M.I.T.

Harold E. Edgerton Assistant Professor for two years. The fund was established by the M.I.T. Corporation to honor Professor Edgerton and his wife, and to provide new horizons in research and career development for younger faculty. Alan's research has been mainly on transduction properties of collagen and other membrane structures, with application to implantable medical assist devices. . . . **Peter V. Hwoschinsky** received the first William E. Jackson Award, presented by the Radio Technical Commission for Aeronautics of Washington, D.C., for his outstanding work in the field of aviation systems. The award was for Hwoschinsky's thesis on the OMEGA navigation system for general aviation. His research was supported by a grant from N.A.S.A.

Robert A. Dennis, '70, recently joined the Bond Department of the Boston Office of Scudder, Stevens & Clark, one of the largest independent investment counseling firms in the country. Mr. Dennis was previously Budget Division Director of the Human Resources Administration of the City of New York. . . . **Thomas C. Holland** received his M.S. in biophysics from Penn State in November, 1975. — That's all. I hope as many of you attend our reunion as are able. Please write. — **Hal Moorman,** Secretary, 3461 McFarlin, Dallas, Texas 75205

72

Neville Anthony Powers, a consultant in architectural acoustics, writes: "Over the last three years, I have worked on performing arts, architectural acoustics and noise control projects, including auditoria, schools, office buildings, apartments and subway stations. I have also developed computer programs for drawing loudspeaker clusters and for calculating and drawing theater sight-line sections." . . . **Bob Schulte** reports: "After getting my M.B.A. from Harvard in June, I went to work for Owens-Illinois in Toledo as a long-range planner in corporate headquarters. I married Susie Littmann, June 28, in St. Louis. **Jack Cater, Ken Weisshaar,** Bob Dresser '71, Bill Michels, '70, and Rich Hartman, '74 attended."

Terrill Chang says: "Am in Seattle working as a consulting mechanical engineer. Have occasionally helped Bruce Rummel, '71, run the Potluck West Coffeehouse at the University of Washington. Rumor (totally unsubstantiated) has it that **John Gunther** may start Potluck North in Anchorage." . . . **Richard Pini** writes: "After four years at the Institute and four more at the big planetarium in Boston, I'm now under a smaller dome and back in high school, developing a new astronomy curriculum as well as teaching and directing."

Irith Dror is a Ph.D. student in mathematical statistics and operations research at Columbia. . . . **Thomas DiPrete** completed his M.A. in mathematical statistics, also at Columbia, and is looking for a dissertation topic for his Ph.D. in sociology. . . . **Dave McDonald** is still at M.I.T. working on a doctorate at the Artificial Intelligence Lab. "Is anybody from 4th west East Campus out there?" he asks. . . . **James Lamiell** graduated from the University of Colorado Medical School in March and joined the army. . . . **Paul Levy** is Deputy Director of the Massachusetts Energy Policy Office advising the Governor and cabinet on matters of energy policy.

James Roxlo is still working for DuPont and is engaged to Rita Heckrotte, a Ph.D. candidate in civil engineering at Carnegie-Mellon. . . . **Richard Scordato** got his M.S. in E.E. in September from the 'tute and is working for Medical Lab Automation in Mt. Vernon, N.Y., as a project engineer. . . . **Andy Moysenko** is working for Raytheon Research Division in Waltham and is involved in materials characterization, inventory, and quality assurance for the Gallium Arsenide Epitaxial Laboratory. . . . **Richard Levin** married Nancy Beren two years back and after graduating from Yale Law School and becoming a member of the California bar, went to work for the House Judiciary Committee, Subcommittee on Civil and Constitutional Rights, doing staff work on the rewriting of the bankruptcy laws.

Doug Bailey has been working for Foster-Miller Associates, an engineering firm in Waltham, since finishing his graduate work last year. His wife Sara is teaching in Chelsea. They spend much of their free time in furniture woodworking projects. Doug plans to go to business school.

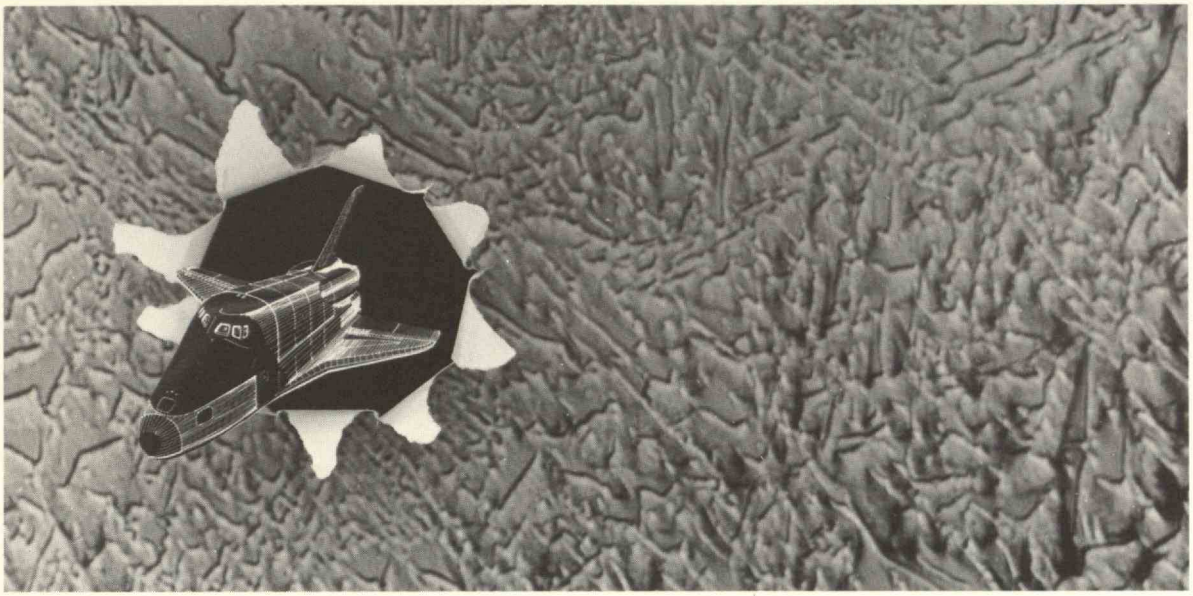
Chuck Ward writes: "I'm quite involved with simulation modeling of air pollution with the California Air Resources Board. Everything is going well. Jan and I will be celebrating our 4th anniversary, the solar-heated home we own is beautiful, but I sure wish we lived in the mountains instead of the great valley." . . . **Larry Klein** is in his senior year of med school at Johns Hopkins and spent last summer doing medicine in Cleveland and Rochester. He will be a medical intern next year. . . . **Lorenzo Lara-Carrero** writes: "I got my Ph.D. in pure math at the Institute last September and am working at the Venezuelan government Institute for Scientific Investigations as a research mathematician. My main interest is pure math (differential equations) but the oil boom here is drawing the interest of many people into applied and technological research, including mine of course. The idea is to take advantage of the oil boom to develop other areas, especially electronic and metallurgical industries, which could substitute for oil as sources of income."

Steve Tavan joined Draper Lab as a programmer in the M.I.S. section of the digital computer department. He and his wife have bought a lovely Victorian (82-years-old) house in Reading. . . . **Alfred Morgan** writes: "I'm working in Philadelphia for Equifax, Inc. My wife, Susan Dalowitz Morgan (Wellesley '72) and I had our first child, Benjamin, in December. All friends are invited to look us up when they come to Philly for the Bicentennial." . . . **Gerry Zuckier** writes: "After dodging, skipping and punting for a few years, I finally had to pass my preliminary exams. Now it's back to the 'tute Bio Dept. to stall for awhile more (seen the Ph.D. hiring statistics lately?) Meanwhile my life is enriched by a new addition, the pitter-patter of little feet around the apartment. Yes, I now have a purebred Bouvier des Flandres."

C. K. Sollitt reports: "I am teaching undergrad and grad courses in fluid mechanics and applied hydraulics at Oregon State. My current funded research topics include estaurine sediment transport and wave interaction with floating structures. My wife, Melissa is teaching at Oak Grove elementary school." . . . **Jerry Greer** was recently in charge of economics, marketing, and feasibility studies in Asia, the Middle East and Latin America for Charles T. Main, Inc. Currently he is in charge of the development of computer-based econometric programs and is assisting in the implementation and verification of the Markov Model for demand forecasting. He was recently in Vienna for an International Atomic Energy Agency meeting. — **Dick Fletcher,** Secretary, 135 West St., Braintree, Mass. 02184

Conversation Pieces

Planning for Breakthroughs in Materials Technology



What can the Space Shuttle and Spacelab programs really be expected to do for technology and, ultimately, for mankind? Well, let's ignore the gee-whiz stuff. Let's stick to practical probabilities, beginning with medical technology.

Manufacturers of serums, vaccines, antibiotics, and other biomedical products, strive constantly for purity. But, on earth, it's very difficult to separate different kinds of living cells. It only takes a tiny minority of unwanted cells to contaminate an almost perfectly purified culture. Minute differences in the electrical charge on each type of cell could be used to achieve significantly better separation if it weren't for gravity. So, suspend your media in zero-g, apply an electrical field and various cells can be withdrawn with the most delicate precision.

Or, suppose you're a metallurgist, interested in alloys; earth's gravity tends to separate the components of many melts as they cool and harden. In zero-g, mixtures tend to stay uniformly mixed. The same goes for cool mixtures of fluids that differ in density. Immiscible on earth, they're easily kept homogeneous in zero-g.

Crystal-growers face similar problems. The benefits that zero-g processing can bring to makers of semiconductors alone are considerable. As for that curious noncrystal, glass, the prospects for optical technology are exciting, to say the least.

One of the greatest attractions of space manufacturing is containerless processing. On earth, even vessels that seem perfectly clean can actually contaminate their contents by reacting at the high temperatures that are essential to many processes. In zero-g, you can contain melts in electrostatic, magnetic, or acoustic fields; power requirements are low yet contaminants are quite easy to keep out.

The combination of zero-g and vacuum, that's available in orbital flight, is expected to facilitate developments in materials technology that range from difficult to impossible on earth. But the breakthroughs, whether they're surprising or reasonably predictable, aren't going to come automatically. It's going to take very careful planning.

At TRW, we have a team of systems engineers working the cost, schedule, and technical tradeoffs right now. They're supported by biologists, chemists, and physicists, who cut their teeth on difficult processing problems. We're working closely with NASA and other government agencies and we're teamed on specific projects with Beckman Instruments, Owens-Illinois, and U.S. Steel. By starting so early and proceeding with care, we hope to help develop new materials that will benefit everybody.

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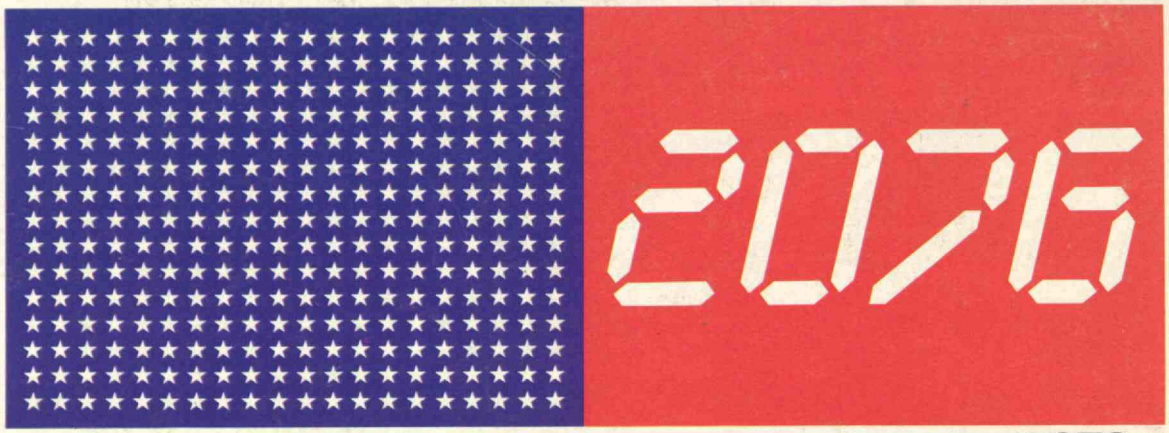

America will change a great deal by the year 2076. Tell us what you think those changes should be.

We have always been a nation more interested in the promise of the future than in the events of the past.

Somehow, the events of the past few years have made us doubt ourselves and our future.

Here at Atlantic Richfield, however, we see the future as an exciting time. The best of times. And we know that all of us can achieve a splendid future by planning for it now.

We'd like your help. We need your vision. We want you to tell us about the changes you would like to see take place in America – and in our American way of life.

For example:
What ideas do you have for making life more fun than it is now?

What changes would you like to see in government? (City? State? Federal?)

What do you envision as the best way to solve our energy problems?

What about the future of business? (More regulation by government? Less?)

What measures would you take to protect the environment?

Or, if those topics don't appeal to you, pick one that does.

How should our physical world be altered? Do you recommend that we live underground? In plastic bubbles?

Will family life change? Will we choose a spouse by computer? Will divorce become illegal?

What should our schools be like? Should machines replace teachers?

What will make us laugh? What will be funny that isn't funny now?

What new major sports would you like to see? Three-dimensional chess? Electronic billiards?

Whatever your idea may be, we want to know about it. Write it. Draw it. Sing it. But send it.

In about six months we plan to gather your responses, analyze them, and make a full report on what we've found out. We believe the report will provide a fascinating and valuable view of America's hopes, dreams, fears, and visions. We'll make sure it reaches the people who are in positions to consider and act on it.

Along the way we will make television commercials and newspaper and magazine ads out of many of the ideas so you can see what other people are thinking.

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